REGIONAL ANATOMY

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IN ITS RELATION TO

MEDICINE AND SURGERY.

BY

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ILLUSTRATED FROM PHOTOGRAPHS TAKEN BY THE AUTHOR OF HIS OWN DISSECTIONS, EXPRESSLY DESIGNED AND PREPARED FOR THIS WORK, AND COLORED BY HIM AFTER NATURE.

Have earlier

"L'anatomie n'est pas telle qu'on l'enseigne dans les écoles."—BICHAT.

IN TWO VOLUMES.
VOL. I.

SECOND EDITION.

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J. B. LIPPINCOTT COMPANY
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TO THE MEMORY

OF MY FATHER,

JOHN H. B. McCLELLAN, M.D.,

AND OF MY GRANDFATHER,

GEORGE McCLELLAN, M.D.

PREFACE TO THE SECOND EDITION.

THAT five thousand copies of Regional Anatomy have already been disposed of in America and England, and that the text is in progress of translation into French and German, are gratifying proofs of its favorable reception by the profession.

In venturing to present a second edition the author takes occasion to acknowledge the many kindly notices and reviews which have been bestowed upon his work.

The text has been thoroughly revised, and the reproduction of the illustrations from the original stones has received unremitting care from the lithographers, whose experience has enabled them to overcome some of the difficulties of producing the desired colors on the steam press, so that it is believed in this respect their work will be found to excel that of the first edition.

The stones from which the illustrations of the brain are now presented have mostly been re-drawn from the original photographs.

No one can more fully realize the shortcomings of the work than does the author, who assures his readers that he will at all times be grateful for any suggestions which may occur to them as likely to render his effort more complete and thereby assist him in his chief aim, the advancement of the knowledge of anatomy.

BROAD AND SPRUCE STREETS,
PHILADELPHIA, May, 1894.

PREFACE TO THE FIRST EDITION.

THERE has been a great deal said of the importance of anatomical knowledge, which is universally conceded to be the foundation of the study of medicine.

As a teacher of anatomy, I have used all my influence to impress this on the minds of students, assuring them that the best book on anatomy is, and always will be, the *body itself*.

In the curricula of the colleges and universities this is emphasized by a compulsory course in the dissecting-room, and each candidate for a degree is obliged to dissect three parts—the head, and the extremities, with contiguous portions of the trunk—at least once. From the knowledge gained by these dissections, and from lectures and text-books, a student is supposed to acquire the information necessary to enable him to work intelligently and beneficially in his profession. He is expected to learn anatomy from his three parts.

Considering the facts that the first part is generally wasted in acquiring the methods of using the instruments; that all the parts are seldom carefully injected with proper preservative; that the student rarely has the opportunity of *seeing* the viscera of the cranium, thorax, and abdomen *in situ*, much less of examining them and noting their size or structure and their relative positions to one another and to the cavities which contain them; and that often the value of the opportunity is not estimated until it is lost, it cannot be a matter of wonder that students look upon anatomy as one of their chief difficulties, and that only a few continue its study after graduation. There are many practical obstacles in the way of obtaining better and more abundant material for such research; but, after some years' experience, I am forced to acknowledge that, even if these obstacles were overcome, the distaste for the actual labor of dissecting, which, besides being exacting, is associated with much that is revolting, and even hazardous to health, would deter many students from gaining that practical knowledge from personal observation which would enable them to recognize the different tissues by the sense of touch as well as by the sense of sight.

In a crowded lecture-room only those who are very near can see the demonstrations so as really to profit by them. Extempore drawings are of great value in awakening and retaining the interest of students, whose memories are often overtasked, and have an advantage over the most carefully prepared diagrams, models, or preparations; but there

cannot be any means of illustration equal to the real thing in teaching, and the best substitute is that which aims at producing the most realistic impressions. Such illustrations have been attempted in the plates for the present work.

Regional Anatomy, or the anatomy of the different regions of the body individually considered, in the relations of their parts to one another, as they are naturally found, is really the most direct method of studying the subject. It is also the most useful form of anatomical research, and, although it may at first sight seem more difficult because it presents a complex in the place of a simple object, such as was demonstrated in the old method of considering the bones, the ligaments, the muscles, the vessels, and the nerves as so many distinct structures, the greater interest soon growing from the evidence of its practical usefulness fully compensates for the effort required.

The interest which my classes have shown in this treatment of anatomy has led me to undertake this work. It is largely the result of information acquired by dissecting, and of clinical observations in hospital and private practice. In its preparation I have consulted such ancient and modern books on anatomy as I could obtain, and have gleaned from them much information which suggested many of the dissections showing relations of structures. No quotation from or direct reference to these works, however, is introduced in the text, which has also, for the sake of clearness, been kept free from notes.

Assuming some previous knowledge of the bones on the part of the reader, I have exercised the privilege of adopting such modifications in the nomenclature as may render certain parts more easily comprehended, but have retained such names and terms as have an historic association, believing that they add to the interest and fasten themselves on the memory, rather than detract from the mastery of so difficult a study. It is to be regretted that anatomy loses much in consequence of the want of a definite nomenclature. The suggestions of modern writers as to technical terms, if accompanied by a corresponding clearness of description, might be of benefit to the student; but, while not underrating the importance of scientific exactness of expression, I am of the opinion that the ordinary student's attention soon wearies of technicality, whether written or spoken, and I have therefore made use of such terms in my text as experience has shown to be most easily understood and remembered. Anatomy, to be of use, must be made a practical and not a theoretical study. It is difficult enough *pro re nata*, and, if hard, need not be dry.

Should the present book fulfil its mission, it will be by presenting the matter in a new form, which it is hoped will prove interesting and useful, alike to the practitioner and to the student who intends to practise. The plates are expressly prepared to illustrate and verify the descriptions, and are as faithful representations of the dissections as they could be made. It should be borne in mind, however, that no true picture of the actual subject will have the distinct demarcation and clearness of a diagram, any more than the representation of a natural landscape indicates mountains, rivers, and boundary lines with the exactness of a map. Diagrams will therefore always be useful to the student in showing him what he ought to see, but such illustrations as are here attempted

should be valuable in enabling him to recognize things as they actually are. These representations are intended to meet the need both of the beginner in dissecting, who is appalled by the want of correspondence between that which he actually sees and that which he has been led to expect by diagrams or description, and of those whose time is too gravely occupied by the pressure of professional duties to warrant their dissecting for themselves. Accuracy has been the chief object, and I have relied upon the unfailing precision of the camera to present the true relations of the parts, which were in each case left *in situ*, only the adipose and connective tissues being removed, to give distinct impressions. Much thought, time, and expense have been given to the photographic details, such as the arrangement of the light to modify the shadows, the exposure and development of the negatives, and the subsequent printing and toning of the pictures to get the desired effect for the application of the water-colors. The coloring of the originals from which the plates were made on stone, under my personal supervision, was a study from nature, with perhaps some excess of tint or shade, as might be expected where the paints were mixed and applied with more enthusiasm than artistic skill.

The dissections, in all about three hundred, were invariably the work of my own scalpel, and were all done upon subjects selected as best showing the normal relations of the parts, without pathological change, while such facts as seem valuable regarding the condition or modes of preparation are mentioned in the description of every plate. Each figure is also accompanied by a separate and complete explanatory table,—every number being placed in regular order, so that any object may be readily found.

To Messrs. Lippincott Company, the publishers, my thanks are due for the warmth with which they have entered into my undertaking, for the strong sympathy and interest they have shown in my work, and for the care which they have taken to present the text to the reader in a clear and attractive form.

To Messrs. Armstrong & Co., of Boston, I am indebted for their painstaking fac-simile reproductions of my systematized views of dissections, which preserve the photographic accuracy and the realistic effect of the coloring of the originals, and which not only ought to render this an acceptable text-book, but should also awaken a keener interest in the study of Regional Anatomy.

GEORGE McCLELLAN.

PHILADELPHIA, OCTOBER, 1890.

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REGIONAL ANATOMY.

REGIONAL ANATOMY

IN ITS RELATION TO

MEDICINE AND SURGERY.

THE REGION OF THE HEAD.

The surface-form of the head is always pronounced, because the prominences and depressions, or *landmarks* (Plate 1), of the skull are slightly masked by the overlying soft structures.

The thickness of the skull-cap varies greatly, and can only be conjectured from external appearances. The average thickness is five millimetres, or one-fifth of an inch; the thickest parts are in the basilar portions, which are originally developed in cartilage, whereas the bones composing the vault are formed in membrane. In no other part of the skeleton is the combination of strength and lightness so beautifully adapted to its purposes as in the cranium.

The contour of the head itself tends to avert the effect of external violence received at any point, and the natural eminences and processes occur where protection to the brain is most needed, while in those parts where it is less needed the bones are thin and light, so as to serve as a covering with but little extra weight.

The hollows or sinuses of the cranial bones are rudimentary at birth, and remain of small size up to about the ninth year, after which they gradually increase until puberty, when they undergo great enlargement.

The bones of the cranium are the frontal, two parietal, occipital, two temporal, sphenoid, and ethmoid. They are immovably connected in the adult at their edges by the *sutures,* which vary in character according to their position and adaptation. The frontal bone is originally developed in two portions, which become joined by the *frontal suture* shortly after birth. This suture usually closes rapidly, so that it is obliterated between the second and sixth years, but occasionally it may persist to the end of a long life. Continued backward approximately in the middle line from the root of the nose and along the course of the frontal suture to the occipital bone is the *interparietal* or *sagittal suture,* by which the two parietal bones are dovetailed together. The parietal bones are connected with the frontal bone by the *coronal suture,* and with the occipital by the *lambdoid suture.* The coronal suture is more deeply indented laterally than above, and the lambdoid is remarkable for the tortuous course of its deep dentations. The junction of the coronal and sagittal sutures, the *bregma,* may be ascertained on the living head by drawing upward from the external auditory openings two lines, which will meet over this point on the top of the head when it is held in the erect position.

The point of junction of the lambdoid and sagittal sutures, the *lambda,* is in the middle line, one-third of the distance from the external occipital protuberance to the bregma. The lambdoid suture may be represented by a line drawn from the lambda to the apex of the mastoid process on each side. The coronal suture corresponds to a line drawn from the bregma to the middle of the zygomatic arch. The point where the anterior inferior angle of the parietal bone is joined to the great wing of the sphenoid bone is the *pterion,* and is three centimetres, or about an inch and a quarter, behind the external angular process of the orbit. At the sides, the arches of the skull are maintained by the thin scaly margins of the temporal bones overlapping the bevelled lower edges of the parietal bones, forming the *squamous sutures.* The top of each squamous suture is five centimetres, or about two inches, above the zygoma in the adult head.

The dentate sutures are formed by serrations mainly from the *outer*

table of the bones of the vertex interlocking. They gradually disappear after the fortieth year, the cranial bones becoming fused together in old age (synosteosis), when they, like the rest of the skeleton, become more porous and brittle and are in consequence more readily fractured.

The closure of the cranial sutures usually begins on the *inside* of the vault, but there is great variability as to the time and order in which it takes place.

The age of an individual cannot be determined from the state of the cranial sutures. They sometimes disappear at an early age. The author has several specimens where not a sign of the coronal, sagittal, or lambdoid sutures remains at the ages of thirty-three and thirty-seven years.

At birth all the tabular bones are soft and yielding and capable of overlapping one another, thereby facilitating the delivery of the head of the child. In the subsequent growth of the bones the compact layers are produced, forming the *outer* and *inner tables*, with an intervening cancellated structure, the *diploë*. In old persons the diploë is often absorbed, so that the skull in some places becomes very thin, and it should be borne in mind that the plane of the inner table is not always equidistant from that of the outer, a matter of no little moment in applying the trephine.

The limiting membranes of the vertex bones are united at the lines of the sutures, and until ossification is completed there are interspaces at the angles of the parietal bones, known as the *fontanelles*. These usually close in shortly after birth, with the exception of the anterior fontanelle, which occupies the bregma and does not disappear until the end of the second year. Until this is completely closed by ossific matter, there is a depression in this locality, through which there is a regular pulsation perceptible, due to the action of the arteries of the brain. Persistence of the anterior fontanelle is generally indicative of hydrocephalus.

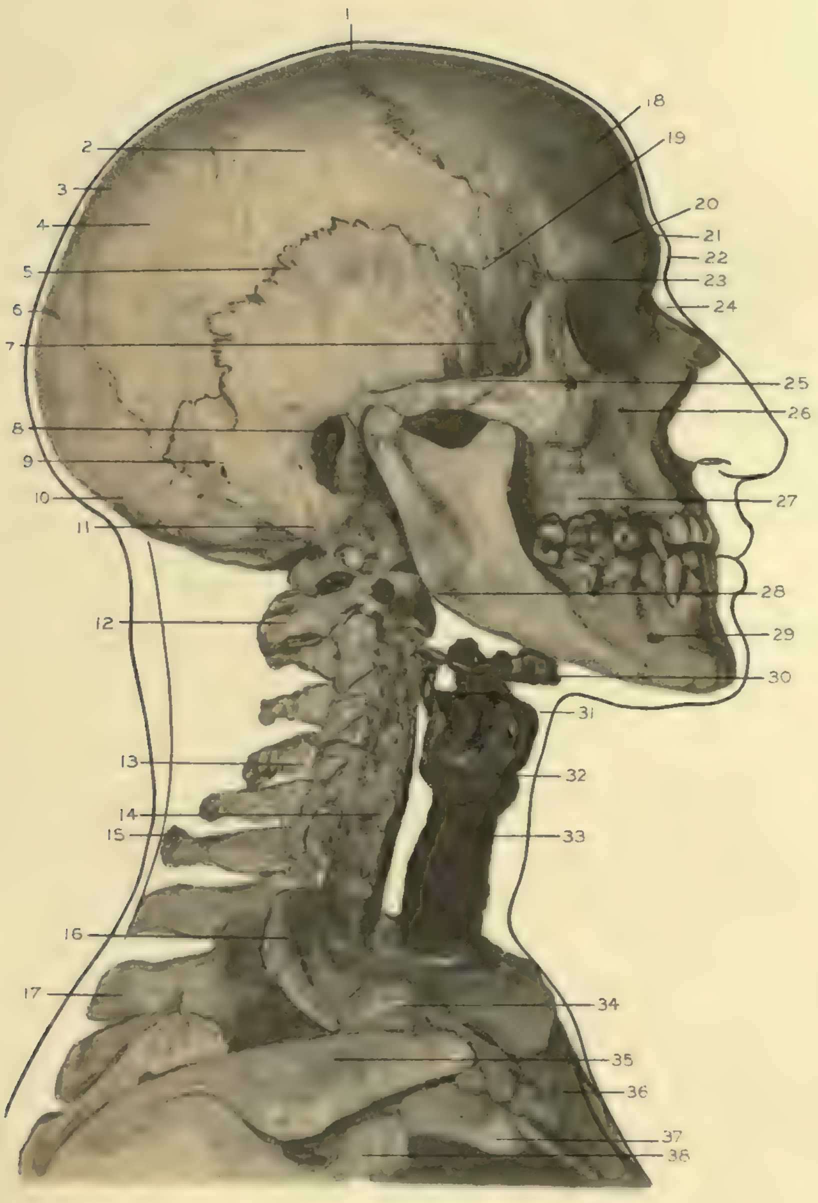
Occasionally congenital fissures occur before the normal approximation of the skull bones is completed. They most commonly occupy the occipital region, and when they persist in the position of the lambdoid

PLATE I.

The landmarks of the skeleton of the regions of the head, face, and neck, on the right side, with their relations to the surface coverings.

1. The point of junction of the coronal and sagittal sutures (*the bregma*).
2. The temporal ridge, for the temporal fascia.
3. The parietal foramen (*the obelion*).
4. The parietal eminence.
5. The squamous suture.
6. The point of junction of the lambdoid and sagittal sutures (*the lambda*).
7. The great wing of the sphenoid bone (*the pterion*).
8. The external auditory meatus.
9. The mastoid foramen (*the asterion*).
10. The external occipital protuberance (*the inion*).
11. The mastoid process of the temporal bone.
12. The spine of the second cervical vertebra.
13. The spine of the fifth cervical vertebra.
14. The transverse process of the sixth cervical vertebra, with first foramen for the vertebral artery.
15. The spine of the seventh cervical vertebra (*the vertebra prominens*).
16. The first rib.
17. The spine of the second dorsal vertebra.
18. The frontal eminence.
19. The anterior inferior angle of the parietal bone.
20. The supra-orbital foramen.
21. The superciliary ridge (*the ophryon*).
22. The glabella.
23. The external angular process.
24. The junction of the frontal and nasal bones (*the nasion*).
25. The zygomatic arch.
26. The infra-orbital foramen.
27. The second upper molar tooth.
28. The angle of the lower jaw (*the gonion*).
29. The mental foramen.
30. The top of the hyoid bone.
31. The top of the thyroid cartilage.
32. The cricoid cartilage.
33. The second ring of the trachea.
34. The acromial end of the clavicle.
35. The acromion process of the scapula.
36. The top of the sternum (*the manubrium*).
37. The coracoid process of the scapula.
38. The glenoid fossa of the scapula.

N. B.—This plate was taken from the skeleton of a well-developed European male, aged about thirty-seven years.



Dissected Photographed and Colored from Nature by George McClellan, M.D.

Armstrong & Co. Lith. Boston

sutures they may be mistaken for fractures. In this locality also are frequently found isolated triangular bony pieces (*Wormian bones*), originating from accessory centres of ossification (Plate 3, Fig. 3, Nos. 4 and 13). Supernumerary bones are also often found in hydrocephalic skulls.

The *superciliary ridges* are the prominences which support the eyebrows. They indicate in a measure the size of the *frontal sinuses* within the bone, which are first formed by absorption of the spongy substance (diploë) at the inner angular processes of the orbits, and gradually spread upward and outward.

The dimensions of the frontal sinuses (Plate 12, No. 25) cannot always be foretold by the external conformation of the ridges; and they often appear to be formed by a retrocession of the inner table, especially in elderly people. They reach a greater degree of development in the male than in the female. They are usually unsymmetrical, the larger being on the side from which the nasal septum is bent.

The frontal sinuses connect with the anterior ethmoidal cells and the middle meatus of the nose by a curved canal called the *infundibulum* (page 113). The intervening point between the two superciliary ridges is called the *ophryon.* Above the ridges are the *frontal eminences* (Plate 2, No. 4, and Plate 28, No. 35), indicating the centres of primary ossification of the original two halves of the frontal bone of infancy, and corresponding in a measure to the development of the anterior lobes of the cerebral hemispheres. The *glabella* is the smooth area between the superciliary ridges above the nose. Just below it is the point of junction of the nasal bones with the frontal spine,—the *nasion.*

The *external angular processes* of the orbits are the outer limits of the superciliary ridges. The glabella and the angular processes are subcutaneous, the ridges being covered by the superciliary muscles and integument (Plate 1). The *supraorbital foramen* or *notch* is on the border of the orbital arch, just below the superciliary ridge, two and a half centimetres, or about an inch, from the external angular process.

The *temporal ridge*, for the attachment of the temporal fascia, starts from the external angular process and arches backward, usually mid-

way between the squamous and sagittal sutures. The temporal muscle is attached one centimetre, or about half an inch, below the attachment of the temporal fascia, and sometimes a second distinct ridge is noticeable on the cranium. The point of intersection of the upper temporal ridge with the coronal suture is the *stephanion.*

The *parietal foramina* are approximately midway between the bregma and the external occipital protuberance. They are very near the middle line, and the area of the brain-case in their locality is often flattened. This area is called the *obelion.* The *parietal eminences* are the points where ossification first began in the parietal bones. They are very noticeable, and correspond to the development of the lateral lobes of the cerebrum.

The *external occipital protuberance,* the *inion,* is on a line drawn horizontally backward from the sockets of the incisor teeth of the upper jaw. This process is the thickest part of the cranium, but is not always so prominent that it can be detected through the scalp. From it on each side the *superior curved line* arches outward toward the mastoid process. The *mastoid processes* are hardly noticeable during childhood. There is a continuous formation of new bone from the periosteum on the surface between infancy and puberty, and during this period the process consists of cancellous tissue which can be readily penetrated by the knife in mastoid disease. At puberty this cancellous tissue becomes hollowed by absorption into air-cells, and a larger cavity, the mastoid antrum, all of which communicate with one another and are connected with the tympanum. The antrum is separated from the cranial cavity by only a thin roof of bone (Plate 3, Fig. 5, No. 1). The cells vary in size in different bodies, and on the two sides of the same head. The proximity of the lateral sinus renders it liable to become involved by extension of inflammation in suppurative disease of the mastoid cells, especially in the adult.

The *mastoid foramen* is situated near the junction of the mastoid portion of the temporal bone and the occipital. It is the largest of several foramina in this locality, and transmits a vein to the lateral sinus, and sometimes a small artery to the dura mater.

The petrous portions of the temporal bones are hard and dense upon their surfaces, but, as they are hollowed within for the lodgement of the structures composing the middle and the internal ear, they are liable to fracture. The skull is not inherently strong at its base, and although undoubtedly fractures do occur in this region by transmitted force from blows upon the vertex, yet fracture by *contre-coup* is not now admitted to be so probable as it was formerly thought to be.

The discharge of cerebro-spinal fluid from the ear, which is one of the diagnostic signs of fracture at the base of the skull, indicates that the internal auditory meatus must have been fractured and that a communication has been established between the tympanum and the internal ear.

Sometimes a serous discharge from the ear follows injury to the head, where fracture has not taken place: this is due to escape of fluid from the mastoid cells through a rupture in the tympanic membrane.

Injuries involving the base of the skull must of necessity be serious, as in this region the cavity of the skull is in relation with the nasal cavity, the orbit, the frontal sinuses, the sphenoidal sinus, the tympanic cavity, the upper part of the pharynx, and the spinal cord. Besides these there are the foramina which give exit to the cranial nerves (Plate 3, Figs. 1 and 5; Plate 4, Fig. 2; Plate 5, Fig. 2; Plate 11, Figs. 1 and 3; Plate 12; and Plate 13).

The skin covering the head, which constitutes the **scalp**, is peculiarly constructed for the growth of the hair and for protection to the vault of the cranium. It is thicker than in any other part of the body, and is closely connected by means of the subcutaneous tissue with the aponeuroses of the occipito-frontales muscles, so that it moves freely with their contraction. This mobility is very noticeable in infancy. The readiness with which the whole thickness of the scalp gives way in contused wounds is due to the intimate connection between the skin and the subjacent textures.

The subcutaneous tissue here consists of a dense fibrous structure enclosing fat lobules (Plates 9 and 12), and resembles that of the palm of the hand. This continues with the superficial fascia over the muscles at the back of the neck, and at the sides passes over the temporal fascia.

The vessels, nerves, hair-bulbs, and sebaceous glands are contained within the meshes of this subcutaneous tissue.

The *scalp hairs* mostly diverge from the obelion. They vary in character according to their color, length, and diameter, and the manner in which the hair-follicles are set in the skin, being straight, wavy, curly, or woolly, according to the straight or the curved axis of each follicle. Fair hairs are finer and more delicate than dark hairs, and are usually more closely set in the scalp.

The arteries of the scalp are the terminal branches of the temporal, supra-orbital, frontal, posterior auricular, and occipital. They pass toward the vertex of the head, running in a tortuous course from their origins. The *temporal artery* is the continuation of the external carotid artery after it has tunnelled through the upper part of the parotid gland (Plate 18, No. 37). It is six millimetres, or a quarter of an inch, in front of the ear, and is accompanied by the temporal vein and the auriculo-temporal nerve. It divides into the anterior and middle temporal branches, which run immediately under the skin (Plate 17, No. 1), and may serve to indicate the pulse to the physician. The *supra-orbital artery* ascends with the supra-orbital nerve (Plate 18, No. 1) from the supra-orbital notch, or foramen, which is situated two and a half centimetres, or about an inch, from the outer orbital angle, toward the nose on the border of the orbital arch. The *frontal artery* and supra-trochlear nerve (Plate 19, No. 1) pass upward between the supra-orbital notch and the root of the nose.

The supra-orbital and frontal arteries come from the ophthalmic artery within the orbit. The *posterior auricular artery* and the *occipital* (Plate 20, Nos. 45 and 50) are branches of the external carotid artery. The former passes with the posterior auricular nerve in a groove behind the mastoid process of the temporal bone, and the occipital artery, accompanied by the great occipital nerve, reaches the scalp at a point midway between the external occipital protuberance and the mastoid process. The anterior branch of the temporal artery often becomes very tortuous in the aged, and sometimes undergoes calcareous degeneration.

Owing to the toughness of the scalp in which the arteries ramify, they

cannot be drawn out, and do not retract when divided, as they do elsewhere, and hence incised wounds in this region are frequently attended with troublesome hemorrhage.

The veins of the scalp are quite large, and in a measure accompany the arteries, receiving similar names in their different localities, but their course is more direct and they freely anastomose. There are two *frontal veins,* which generally run parallel at the middle of the forehead, sometimes being very prominent in life, and are united at the root of the nose by a transverse trunk called the nasal arch. Thence they branch into the angular veins of the face, being joined by the supra-orbital veins. At this point they receive branches from the superior ophthalmic veins and establish direct communication with the cavernous sinuses at the base of the brain. Sometimes there is only *one* temporal vein.

The *temporal veins* commence by anastomosing plexuses on the top of the head which form into anterior and posterior branches, and unite into main trunks in close relation to the temporal arteries at the zygoma, where they receive the blood from the middle temporal veins coming from the substance of the temporal muscles. The *posterior auricular veins* descend behind the ear, receiving the stylo-mastoid veins, and empty into the temporo-maxillary veins. The *occipital veins* follow the course of the occipital arteries, passing beneath the deep muscles at the back of the neck and terminating usually in the internal jugular veins. At the mastoid portion of the temporal bone the *mastoid vein* enters the occipital or the posterior auricular, thus communicating with the lateral sinus. This is the largest and most constant of the so-called *emissary veins,* which connect the extra- and the intra-venous circulation. Besides the intercommunication by the ophthalmic and angular veins and the mastoid and occipital veins, there are many others which are less constant, but of equal importance when they do occur. The parietal foramina are at the vertex in the vicinity of the median line, where the interlocking of the serrated edges of the parietal bones forms the sagittal suture, and transmit veins from the scalp to the longitudinal sinus. There is generally a vein connecting the lateral sinus with the deep veins at the

back of the neck through the posterior condyloid foramen, on one side or the other; and there are many apertures at the base of the skull through which veins pass connecting the cavernous sinuses with the venous plexuses of the pharynx and the internal jugular veins. A similar connection exists more often than is supposed between the veins of the nasal fossæ and the front part of the longitudinal sinus through the *foramen cæcum*, which in such cases is not closed. There are also minute veins which connect the diploic veins (Plate 3, Fig. 4) within the tabular bones of the skull with the veins of the scalp. The emissary veins are well worthy the attention of the physician or surgeon, for through their various channels inflammation often spreads from the surface to the interior of the head, or the reverse; as is witnessed where erysipelas of the scalp induces meningitis, or in external abscess following injury to a sinus by a fracture or the application of the trephine.

The lymphatic vessels of the scalp are in relation to the principal veins. The *frontal lymphatics* descend from the forehead and eyebrows, some going to the lymphatics of the face and ending in the submaxillary lymphatic glands, while the greater number converge toward the front of the ear, where they enter the lymphatic glands of the parotid region (Plate 16, No. 15). The *parietal lymphatics* pass to the mastoid glands, are four or five in number, and lie about the insertion of the sterno-mastoid muscle. The *occipital lymphatics* go partly to the sub-occipital glands in front of the occipital attachment of the trapezius muscle, and partly to the deep cervical glands beneath the sterno-mastoid muscle at the middle of the neck. The frontal, parietal, and occipital lymphatic vessels all communicate with one another.

The nerves of the scalp have been considered in their relations with the arteries. It will be noticed that they also pass toward the vertex of the head.

In front are the *supra-orbital* and *supra-trochlear* branches of the ophthalmic division of the fifth cranial nerve,—the *trifacial* (Plate 3, Fig. 2). They give sensation to the integument over the top of the head and forehead (Plate 53, Fig. 1, Nos. 1 and 13).

The supra-orbital nerve is often the seat of frontal neuralgia, which

probably depends much upon whether the nerve issues from a distinct bony foramen or only from a notch. In the temporal region are the filaments from the *orbital branch* of the superior maxillary division, and the *auriculo-temporal nerve* from the inferior maxillary division, of the fifth nerve (Plate 19, No. 20). All of these supply sensation. The motor nerves are derived from the temporal branches of the facial nerve, which pass upward from among the lobules of the parotid gland to the anterior portion of the occipito-frontalis, corrugator, supra-auricular, and anterior auricular muscles. Behind are the *posterior auricular branch* of the facial nerve, giving motion to the posterior portion of the occipito-frontalis and posterior auricular muscles, and the *small* and *great occipital nerves* (Plate 22, Fig. 1, Nos. 3 and 8), the former a branch of the anterior division and the latter a branch of the posterior division of the second cervical nerve. These last are the sensory nerves to the skin over the back of the head. The *auricular branch* of the pneumogastric nerve (Arnold's) emerges from the auricular fissure just behind the concha of the ear, which it supplies. The nerves of the scalp communicate frequently with one another.

The cutaneous muscle of the scalp, the occipito-frontalis, consists of two fleshy portions, the frontal and the occipital, united by a broad aponeurosis, which is continuous with the aponeurosis of the opposite muscle across the vertex and forms the *galea capitis* (Plate 15, No. 1). In bald persons the frontal muscles often plainly show in outline on the sides of the forehead.

The *frontal portion* is a thin layer of pale fleshy fibres extending upward five centimetres, or about two inches, on the side of the forehead, where it joins the aponeurosis. In the middle line, at the nasion, the fibres blend with those of the fellow muscle, sending a slip downward to intersect with the pyramidal nasal muscle. The middle and outer fibres commingle with those of the orbicular and corrugator muscles at the eyebrows. Some of the innermost fibres are attached to the nasal bones, some of the outer to the external angular process of the orbit (Plate 15, No. 3). The *occipital portion* is of a darker color than the frontal. It takes origin by a tendinous insertion on the outer part of

PLATE 2.

Figure 1.

Skull showing topographical survey of the relations of the sutures and eminences to the principal fissures of the brain, and the approximate lower level line of the cerebrum.

1. *The bregma*, the junction of the coronal and sagittal sutures.
2. *The superior frontal sulcus.*
3. *The posterior frontal or vertical sulcus.*
4. *The frontal eminence.*
5. *The superior stephanion*, or intersection of the ridge for the temporal fascia with the coronal suture, in its relation to the inferior frontal sulcus.
6. The line indicating the anterior limit of the corpus striatum.
7. *The glabella* (or *ophryon*).
8. *The pterion*, the junction of the great wing of the sphenoid bone with the frontal, parietal, and temporal bones, indicating the position of the ascending branch of the fissure of Sylvius in its relation to the coronal suture.
9. *The nasion*, the junction of the nasal and frontal bones.
10. The external angular process of the orbit.
11. *The fissure of Rolando.*
12. *The inter-parietal sulcus.*
13. *The parietal eminence.*
14. *The squamo-parietal suture* in relation to the horizontal branch of the fissure of Sylvius.
15. The line indicating the posterior limit of the optic thalamus.
16. *The upper temporo-sphenoidal sulcus.*
17. *The external parieto-occipital fissure.*
18. *The lambda*, the junction of the lambdoid and sagittal sutures.
19. *The lower temporo-sphenoidal sulcus.*
20. *The inion*, the external occipital protuberance.

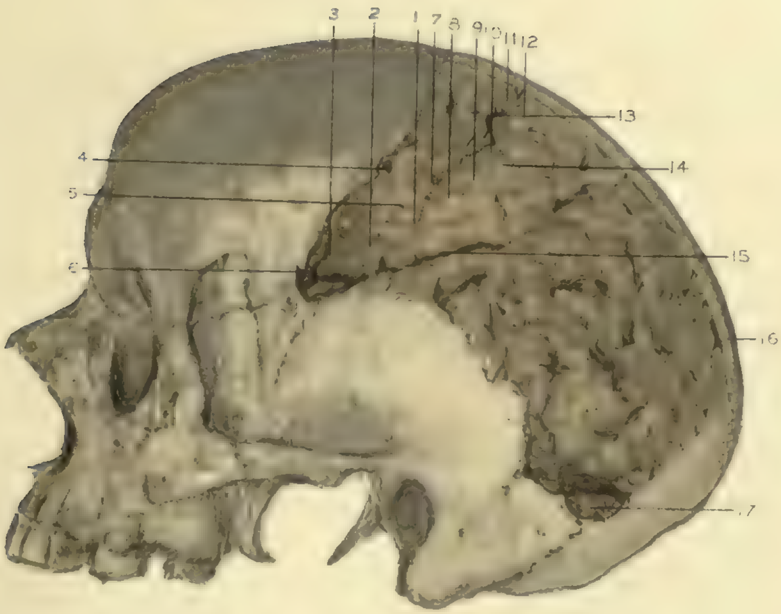
Figure 2.

The left side of skull with the parietal bone removed, showing the subjacent convolutions of the left cerebral hemisphere (stripped of their membranes), with topographical survey of the motor area of the opercular region thus exposed.

1. The centre for the movements of the face (the expressions).
2. The centre for the movements of the lips, tongue, throat, and larynx.
3. The speech centre.
4. The pre-central, or posterior, frontal sulcus.
5. The ascending frontal convolution.
6. The ascending branch of the fissure of Sylvius.
7. The centre for the movements of the fingers.
8. The centre for the movements of the thumb.
9. The centre for the movements of the wrist.
10. The centre for the movements of the shoulder and elbow.
11. The centre for the movements of the hip, knee, and leg.
12. The centre for the movements of the foot and toes.
13. The fissure of Rolando.
14. The ascending parietal convolution.
15. The horizontal branch of the fissure of Sylvius.
16. The external parieto-occipital fissure.
17. The cerebellum.

Fig 1

Fig 2



Dissected, Photographed and Colored from Nature by George Mc Clellan, M.D.

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the upper curved line of the occipital bone and the mastoid portion of the temporal bone, and, immediately becoming muscular, its parallel fibres extend upward three centimetres, or about an inch, and then join the aponeurosis. The *aponeurosis of the scalp* is continuous across the top of the head, and is more characteristic behind, where there is a median area chiefly composed of longitudinal fibres which are attached to the external occipital protuberance and adjoining portions of the upper curved line. It is thinner in front, and at the sides, in the temporal region, it is not so closely associated with the scalp, being continued over the subjacent temporal fascia as far as the zygoma. Between the aponeurosis (*epicranium*) and the delicate membrane overlying the skull bones (*pericranium*) there is a layer of loose connective tissue, upon which the mobility of the scalp depends. This mobility is readily seen in the raising of the brows by contraction of the frontal muscles, in many of the ordinary facial expressions, and the laxity of the connective tissue is demonstrated in extensive scalp wounds, where a large flap may be peeled off from the skull. Incised wounds gape most when they occur across the direction of the fibres of the muscle. The attachments of the occipito-frontales muscles, above described, constitute a limited area of surgical significance in case of wounds and inflammatory affections attended with suppuration in this region. This area is roughly indicated by a line drawn round the head from the superciliary ridges above the zygoma to the occipital protuberance. The pericranium is very thin in the adult, and exercises only a protective influence over the skull bones, playing no part in their nourishment. It is unlike the periosteum elsewhere, being destitute of its bone-producing properties, the bones of the cranium receiving their nutrition from the vessels of the dura mater.

The pericranium may be regarded as the remains of the outer layer of the developing membrane which surrounded the bones in early life. It is very slightly attached, except at the sutures, where, in the young, it blends with the membrane between the soft and growing bones. In the latter instance sometimes extravasations occur, due generally to pressure on the head at birth, which are limited to one bone, commonly

the parietal. In the temporal region the pericranium is more adherent to the bone than anywhere else.

The temporal region corresponds with the temporal muscle, which occupies the temporal fossa. The skin here is somewhat different from the scalp proper, having a variable quantity of fat in its subcutaneous tissue, besides the rudimentary auricular muscles.

The *temporal fascia* is a bluish-white shining aponeurosis, underlying the above, of a very unyielding nature, which firmly binds down the temporal muscle, and sends radiating tendinous slips among the outer bundles of fibres of the muscle which greatly augment its power. Above it is attached to the upper temporal ridge on the frontal and parietal bones, and below it is separated into two leaflets which are inserted into the outer and inner borders of the zygomatic arch. There is usually a pad of fat between the muscle and its aponeurosis at the zygoma, the wasting of which in emaciation and in old age occasions conspicuous hollows at the temples.

When the *temporal muscle* is stripped of its fascia, it presents a fan-shaped appearance (Plate 21, No. 2), with its fibres converging into a strong tendon, which is inserted into the coronoid process of the lower jaw at its apex and anterior border. The temporal muscle arises from the side of the skull one centimetre, or a half-inch, below the attachment of the fascia. Its deeper surface is in relation to the deep temporal arteries and nerves and to the internal maxillary vessels. Its motor nerves are derived from the inferior maxillary nerve. The function of the temporal muscle is to raise the lower jaw forcibly against the upper. With the masseter (page 122) and pterygoid muscles it is concerned in the mastication of food.

The *inequality of the thickness of the skull-cap* has already been mentioned. It depends upon the amount of the diploë between the outer and inner tables of compact bone. This structure varies considerably, and its amount cannot be determined before a section of the bone is made. The diploë contains a number of large veins, which occupy channels in its structure and freely anastomose (Plate 3, Fig. 4) and at points have extra- and intra-communications with the veins of the scalp

and the sinuses of the dura mater. When the diploë is reached by the teeth of a trephine saw, the blood from the *diploic veins* wells up in a peculiar and distinctive manner.

The inner table of compact bone is thinner and more brittle than the outer, and is in consequence called the *vitreous table.* Thus its fracture is accounted for in those cases where it has been broken without the outer table being implicated; and in nearly all cases of complete fracture of the skull bones it is the internal table which is most broken. The egg-shaped form of the skull has undoubtedly much to do with the diversion of the effects of violence from the brain, and explains the possibility of the occurrence of fracture at the base of the skull from *contre-coup.*

When the skull-cap is removed its inner surface is found to be grooved for the branches of the meningeal arteries at the sides, and along the median line about the attachment of the walls of the superior longitudinal sinus of the dura mater are depressions for the reception of the so-called *Pacchionian bodies.*

The dura mater is the white, dense, fibrous membrane which lines the interior of the skull, serving the double purpose of being the true (nutritive) periosteum of the cranial bones and of affording a tough protective envelope and support to the brain. It is closely adherent over the whole of the base of the skull, where it is prolonged through the foramina, becoming continuous with the pericranium and blending with the fibrous sheaths of the nerves and vessels which pass out of and into the cranium. Over the vault its attachments are chiefly in the position of the sutures, where its outer fibrous layer separates to form the venous sinuses. Elsewhere it is comparatively loose, so that extravasations from rupture of the meningeal vessels or purulent accumulations may collect between the dura mater and the bone and cause compression of the brain. When compression occurs immediately on the receipt of an injury to the head, it is generally due to a depressed fragment of bone; but if it follows after an interval it is probably caused by an extravasation of this sort. It is worthy of note in this connection that rupture of a vessel of the dura is usually followed by symptoms of compression more pronounced

than when one of the *cerebral* vessels is involved, owing to the softer and more yielding nature of the brain-substance. On the other hand, when a cerebral vessel is ruptured there is little impediment to the escape of the blood, and often clots of great size are found in the locality of one of the cerebral vessels. Even in the lines of the sutures the dura mater can be severed from its bony attachment by taking pains in the removal of the skull-cap (Plate 4, Fig. 2), and there is little danger of wounding any of the sinuses with the trephine if the button of bone, when it has been cut through by that instrument, is seized with the forceps and extracted by a gentle rotatory motion. During the growth of the skull bones in childhood the dura mater is very adherent, and does not allow extravasations to collect between it and the inner wall of the cranium.

The *Pacchionian bodies*, depressions for which are often noticed on the inner table of the skull-cap, are clusters of whitish granulations of variable size (Plate 5, Fig. 1). They first appear about the seventh year, and increase in number as age advances. The localities in which they are liable to be found are the neighborhood of the great longitudinal sinus, on the outer surface of the dura, and sometimes within the walls of the sinus itself. They are also, but rarely, met with in the fissure of Sylvius and on the margins of the hemispheres. They have been demonstrated to be hypertrophied villi of the arachnoid membrane, which perforate the dura mater by pressing outward, and cause the formation of the pits in the bone by absorption.

The dura mater sends vertical processes between the hemispheres of the cerebrum and those of the cerebellum, and a transverse arching partition between the posterior lobes of the cerebrum and the cerebellum (Plate 4, Fig. 1). The latter is called the *tentorium*, and serves to prevent the posterior lobes of the cerebrum from pressing upon the cerebellum. It is attached to the transverse ridges upon the inner surface of the occipital bone, and extends laterally to the superior borders of the petrous portion of the temporal bones, and forward to the clinoid processes of the sphenoid bone. The vertical processes are known respectively as the *falx cerebri* and the *falx cerebelli*. The falx cerebri

is received into the longitudinal fissure between the two cerebral hemispheres. It is attached in front to the crista galli of the ethmoid bone by a sharp point, and gradually becomes broader as it arches backward, assuming the characteristic shape of the blade of a sickle. At its back part it is connected with the upper surface of the tentorium. The falx cerebelli is projected into the notch between the hemispheres of the cerebellum and extends to the sides of the foramen magnum.

The *arteries of the dura mater* are very numerous, but the one of chief importance is the *great* or *middle meningeal artery* (Plate 9, Fig. 2). This vessel is a branch of the internal maxillary artery, and enters the skull at the foramen spinosum in the margin of the great wing of the sphenoid bone where it joins the anterior inferior angle of the parietal bone, at the middle fossa of the skull. It passes upward over the side of the dura mater in close connection with its two veins, and divides into anterior and posterior branches, which are received by grooves or channels in the inner table of the parietal bone. Very often these channels become in places distinct bony *tunnels*, so that removal of a section of the bone so constructed necessitates the rupture of the embedded artery. At the lower anterior angle of the parietal bone fracture is very liable to occur, because the bone is peculiarly thin and weak, and, although the dura mater is adherent here, in such an injury the vessel can hardly escape laceration. In almost every case of fracture of the *vault* of the skull, attended with extravasation of blood, it is one or other of the branches of the middle meningeal artery which gives way, and this may even occur without fracture, owing to the loose attachment of the dura mater within the vault being separated by the vibration produced by a blow.

The other arteries which supply the dura mater and the various regions of the skull are, in the temporal region, the *lesser meningeal*, which enters at the foramen ovale coming from the internal maxillary (Plate 22, Fig. 2), and a small twig from the *ascending pharyngeal artery*, which comes through the middle lacerated foramen at the base of the skull. Anteriorly there are meningeal arteries from the ethmoid and internal carotid arteries, and posteriorly branches from the occipital, ascending pharyngeal, and

vertebral arteries. The first two enter by the jugular foramen, and the latter by the foramen magnum.

All the *veins of the dura mater*, with the exception of the two which accompany the middle meningeal artery on either side, terminate in the great sinuses. They freely anastomose with the diploic veins. The dura mater not only affords support to the divisions of the brain-mass, but in certain places separates into two layers, so as to form canals, or *sinuses*, by which the venous blood from the brain and its membranes is conveyed without interference to the internal jugular veins.

There are as many as fifteen of these sinuses, but the most important (from a surgical point of view) are the superior longitudinal and the lateral (Plate 4, Figs. 1 and 2). The *lateral sinuses* are the main channels to which all the other sinuses converge. They often differ in size upon the two sides of the head. They commence at the internal occipital protuberance and curve outward and downward and inward to the jugular foramina, being received in the grooves of the occipital and temporal bones and included in folds of the tentorium. In their course they receive veins from the cerebellum and from the occipital diploic veins, and are joined by the petrosal sinuses. They also communicate with the veins of the scalp by *emissary veins* through the mastoid foramina, and sometimes by the posterior condyloid foramina. It is owing to this intercommunication that many cerebral affections are relieved by counter-irritation, or the application of leeches, in this region. The *superior longitudinal sinus* (Plates 4 and 12) is formed by a separation of the layers of the falx cerebri in the line of the sagittal suture. It commences at the foramen cæcum in front of the crista galli of the ethmoid bone, and passes backward, gradually becoming larger, until it reaches the internal occipital protuberance. At this point the sinus deviates, usually to the right side. It becomes dilated and terminates in the corresponding lateral sinus. The dilatation has long been known as the *torcular Herophili*, or confluence of the sinuses (Plate 4, Fig. 1, No. 12).

A transverse section of the superior longitudinal sinus is found to be triangular, with the base of the triangle upward against the skull (Plate 11, Fig. 1, No. 1). Its lower angle is bridged across at intervals by

slender fibrous cords, called *chordæ Willisii.* This sinus receives blood from numerous veins from the adjacent cancellous structure of the skull-cap, from several large veins from each hemisphere of the cerebrum, and through a venous link by means of the parietal foramen from the veins of the scalp. These veins usually enter the walls of the sinus obliquely, passing from behind forward (Plate 4, Fig. 1) in a direction contrary to that of the blood-current in the sinus, probably to prevent regurgitation of blood into the cerebral veins. Very frequently there is a communication between the veins of the nasal fossæ and the apex of the sinus, and in some cases of severe epistaxis the sinus has been supposed to be tapped through such a connection.

The superior longitudinal sinus, from its position, is often subjected to wounds in fracture of the skull, and less frequently in trephining. The hemorrhage resulting is by no means so serious as to warrant great alarm, for there are many recorded cases where such hemorrhage has been easily controlled by gentle pressure. Observation has led to the supposition that the blood circulates more slowly in the sinuses than in the ordinary veins; and their construction seems to be especially for venous receptacles into which a reflux of blood can take place without exercising compression upon the brain-substance. The *cavernous sinuses* are the only other sinuses of importance, and that because of their intimate relations with the internal carotid arteries. Owing to these relations, arterio-venous aneurism sometimes follows injury to the base of the brain. The cavernous sinuses are truly venous plexuses situated at the sides of the body of the sphenoid bone, surrounding the carotid arteries. They receive blood from the anterior inferior cerebral veins, and through the ophthalmic veins from the orbits. This latter communication may lead to thrombosis of the sinuses by extension of inflammation from disease within the orbits along the ophthalmic veins. The cavernous sinuses empty their blood by means of the upper and lower petrosal sinuses into the lateral sinuses.

The *nerves of the dura mater* are the recurrent branches of the fourth and some filaments from the fifth of the cranial nerves. Besides these there have been demonstrated upon the dura filaments from the ophthalmic and hypoglossal nerves, as well as some from the sympathetic nerve.

PLATE 3.

Figure 1.

The base of the skull seen from within, showing the exits of the cranial nerves. The dura mater lining the fossæ of the skull is retained, surrounding and forming sheaths for all the nerves which are left *in situ* after the removal of the brain. (From a female head, aged twenty-one years.)

1. The left olfactory bulb (or first cranial nerve).
2. The left optic nerve (or second cranial nerve).
3. The left internal carotid artery.
4. The optic chiasm.
5. The motor oculi nerve (or third cranial nerve).
6. The trochlearis nerve (or fourth cranial nerve).
7. The trifacial nerve (or fifth cranial nerve).
8. The abducent nerve (or sixth cranial nerve).
9. The facial nerve (or seventh cranial nerve); and the auditory nerve (or eighth cranial nerve).
10. The hypoglossal nerve (or twelfth cranial nerve).
11. The glosso-pharyngeal nerve (or ninth cranial nerve).
12. The pneumogastric nerve (or the tenth cranial nerve).
13. The spinal accessory nerve (or eleventh cranial nerve).
14. The crista galli of the ethmoid bone.
15. The right frontal fossa.
16. The olivary process of the sphenoid bone.
17. The right internal carotid artery.
18. The temporal fossa.
19. The basilar portion of the occipital bone, joining that of the sphenoid.
20. The right occipital fossa.
21. The internal occipital crest.
22. The internal occipital protuberance.

Figure 2.

The distribution of the branches of the trifacial (or fifth cranial nerve), and their relation to the arteries of the face.

1. The supra-orbital nerve.
2. The supra-trochlear nerve.
3. The infra-trochlear nerve.
4. The terminal branches of the lachrymal nerve.
5. The infra-orbital branch of the superior maxillary nerve.
6. The spheno-palatine (sympathetic) ganglion (or Meckel's ganglion).
7. The descending palatine nerves.
8. The infra-orbital nerve and artery.
9. The anterior and posterior dental nerves and arteries.
10. The superior buccal nerve.
11. The inferior buccal nerve.
12. The inferior dental nerve and artery.
13. The mental nerves and artery.
14. The optic nerve.
15. A nasal branch from the infra-orbital nerve.
16. The position of the Vidian nerve.
17. The branches of the inferior maxillary nerve to the muscles of mastication.
18. The ophthalmic nerve (or first division of the trifacial nerve).
19. The anterior branch of the temporal artery.
20. The auriculo-temporal nerve.
21. The posterior branch of the temporal artery.
22. The temporal artery.
23. The middle meningeal artery.
24. The chorda-tympani nerve.
25. The internal maxillary artery.
26. The occipital artery.
27. The posterior auricular artery.
28. The facial nerve.
29. The lingual nerve (or gustatory nerve).
30. The chorda tympani nerve, where it joins with the lingual nerve.
31. The infra-maxillary branch of the facial nerve.
32. The external carotid artery.
33. The internal carotid artery.
34. The common carotid artery.
35. The facial artery.

Figure 3.

The posterior view of a European skull (*the norma occipitalis*). Showing remarkable Wormian bones (or *ossa triquetra*). Nos. 4 and 13.

1. The sagittal suture.
2. The left parietal foramen.
3. The left parietal eminence.
4. The left side of the upper portion of the occipital bone (Wormian).
5. The lambdoid suture.
6. The left asterion.
7. The external occipital protuberance (*the inion*).
8. The left mastoid process.
9. The digastric groove.
10. The obelion.
11. The right parietal eminence.
12. The lambda.
13. The right side of the upper portion of the occipital bone (Wormian).
14. The right asterion.
15. The right mastoid process.
16. The occipital crest.

Figure 4.

The right side of a skull of an adult male, with the outer table rasped away to show the diploic veins.

1. The fronto-parietal veins, which communicate with the superior petrosal sinus.
2. The external parietal veins, which terminate usually in the mastoid vein.
3. The parieto-occipital veins emptying into the lateral sinus.
4. The frontal veins, which communicate with the supra-orbital veins.
5. The fronto-sphenoidal veins, which connect with the deep temporal veins.

Figure 5.

Oblique section through the left temporal bone, to show the tympanic cavity and mastoid cells on one side, and on the other the membrana tympani, the ossicles, and the Eustachian tube.

1. The position of the squamo-petrosal suture.
2. The eminence over the semicircular canals.
3. The depression for the Gasserian ganglion of the fifth cranial nerve on the apex of the petrous bone.
4. The internal carotid artery entering its canal.
5. The tympanic cavity.
6. The pyramid for the stapedius muscle.
7. The stapes resting on the fenestra ovalis.
8. The fenestra rotunda.
9. The aqueduct of Fallopius.
10. Section through the mastoid cells.
11. The squamous portion of the temporal bone.
12. The position of the canal of Huguier.
13. The tensor tympani muscle.
14. The end of the manubrium of the malleus.
15. The osseous portion of the Eustachian tube.
16. The incus.
17. The membrana tympani.
18. The styloid process.
19. The mastoid process.

Plate 3

Fig 1

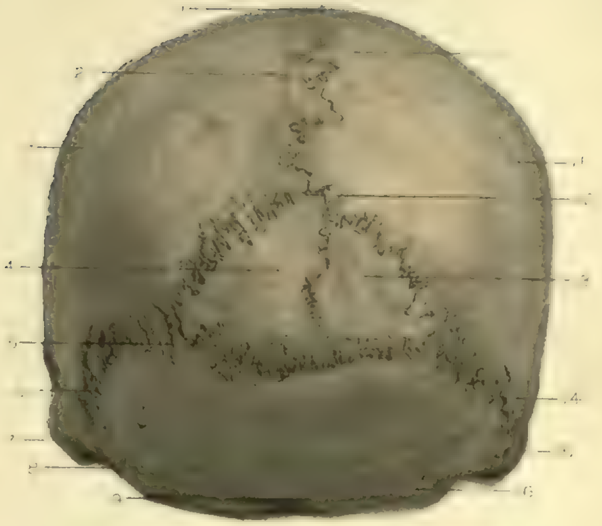


Fig 3

Fig 4

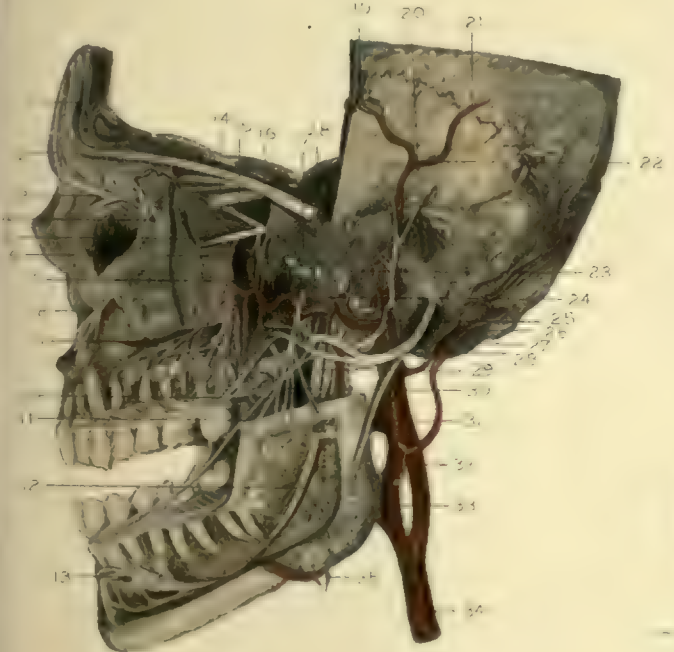


Fig 2

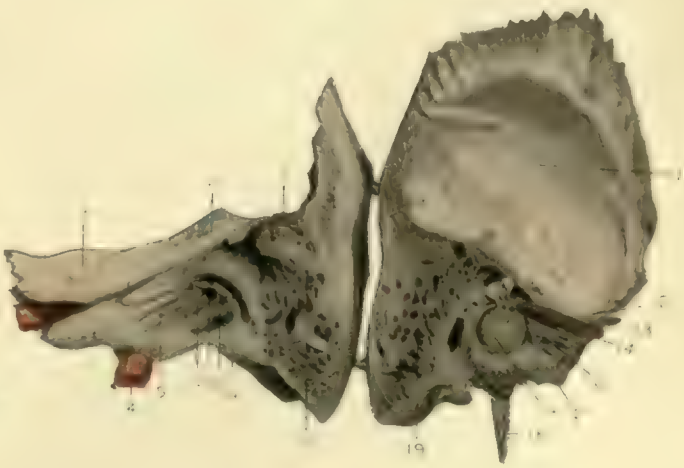


Fig 5

The cerebral surface of the dura mater is lined by the delicate **arachnoid membrane** (Plate 5, Fig. 1), which in the normal state facilitates the pulsations of the underlying convolutions, owing to its property of secreting a serous fluid. The amount of fluid between the dura and the arachnoid tissue is inconsiderable. It is contained within the *sub-dural space*, so called in contradistinction to the *sub-arachnoid space*, which is between the arachnoid membrane and the subjacent vascular tissue,—the *pia mater*. The arachnoid membrane is colorless and extremely thin over the upper surface of the hemispheres, but it becomes thicker at the base of the brain in front and behind the pons Varolii, where it is opaque. At these localities there is always a quantity of serous fluid which serves to support the overlying brain. The arachnoid fluid passes into the interior ventricular cavities of the brain by means of the opening into the fourth ventricle for the *choroid tela* (Magendie's foramen), and thus serves to exert a sustaining pressure both within and without, thereby preventing the ill effects of concussion, and enabling one hemisphere to support the weight of the other when the head rests upon the side. The arachnoid membrane does not unite with the dura except where the cerebral veins pass to the sinuses or around the corpora Pacchioni, and it does not accompany the pia mater into the sulci between the convolutions. The *arachnoid* or *cerebro-spinal fluid* is a limpid liquid with a salty taste and a slightly alkaline reaction. In cases of fracture of the base of the skull, involving the petrous portion of the temporal bone, the escape of the cerebro-spinal fluid through the ear is a diagnostic feature, as previously stated.

The pia mater is a delicate net-work of connective tissue in immediate relation to the surface of the brain, containing within its meshes the ramifications of the cerebral vessels. It closely follows the infolding of the brain-surface, which constitutes the convolutions, and lines the great fissures which characterize the development of the organ, and by some of them is continued into the ventricular cavities. After removal of the dura mater many large superficial veins will be noted passing between the layers of the pia mater to empty their blood into the sinuses (Plate 5, Fig. 1, and Plate 10, Fig. 1). They do not regularly accompany the

arteries, and on the surface of the hemispheres they freely communicate with one another. At the base of the brain the pia mater becomes more dense and fibrous, investing the cerebral crura, the pons, and the medulla oblongata. Here the contained arteries divide into groups of *long* vessels which penetrate the brain-substance and give rise to the *anterior* and *posterior perforated spaces.*

The arteries of the brain are derived from the two *internal carotid arteries,* which enter the base of the skull through the carotid canals in the temporal bones, and from the two *vertebral arteries,* which, after ascending through the foramen magnum, unite to form the *basilar artery* on the surface of the pons. These main sources which furnish the blood to the brain pursue a tortuous course (Plate 3, Fig. 5, and Plate 4, Fig. 2) before they gain entrance into the calvarium, and immediately afterward are disposed in a remarkable inosculation (the circle of Willis) (Plate 5, Fig. 3), for the purpose of equalizing and moderating the flow of the blood in the several parts of the brain. The *internal carotid artery* is surrounded by the *cavernous plexus of veins* by the side of the body of the sphenoid bone, and branches into the ophthalmic, anterior, and middle cerebral, posterior communicating, and anterior choroid arteries. The *anterior* and *middle cerebral arteries* arise from the internal carotid at the inner end of the fissure of Sylvius. The former passes to the longitudinal fissure, where it is joined to its fellow from the opposite side by the *anterior communicating artery;* thence the two anterior cerebral arteries run side by side, supplying the adjacent frontal lobes and corpus callosum. The middle cerebral is the largest branch of the internal carotid (Plate 5, Fig. 3, No. 18). After giving off numerous small branches to the anterior perforated space to go to the corpus striatum, it penetrates deeply into the fissure of Sylvius, furnishing the anterior and middle lobes of the hemisphere. The anterior choroid branch of the internal carotid passes, by means of the slit (the hippocampal fissure) in the middle horn of the lateral ventricle, to the choroid plexus. The *posterior communicating artery* is often of unequal size (Plate 5, Fig. 3) on the two sides, and passes backward to join the posterior cerebral artery from the basilar, thus completing the arterial chain at the base of the brain.

The branches from the posterior cerebral arteries communicate with those from the anterior and middle cerebral. Before the vertebral arteries join to form the basilar they give off small branches in the neighborhood of the medulla oblongata to the contiguous parts, meningeal and spinal branches, and the posterior cerebellar artery on each side. The other cerebellar arteries arise from the basilar. The *basilar artery* also gives off transverse twigs (Plate 5, Fig. 3) as it lies in the median groove on the pons, the *auditory artery*, accompanying the auditory nerve, being one of them. The vessels which penetrate into the brain are accompanied by delicate sheaths from the pia mater, which serve as lymphatic channels communicating with the sub-arachnoid and sub-dural spaces, the great cerebral lymph-spaces.

The chief routes by which the pia mater conveys its capillary meshes into the brain-cavities are by the *transverse fissure*, as the *choroid tela*, into the lateral and third ventricles, and along the roof of the fourth ventricle, forming the *velum interpositum* and *choroid plexus.*

The free intercommunication from side to side of the arteries at the base of the brain is most important, as there is no anastomosis between the arteries of the cortical surface and the arteries of the ganglionic masses. Softening of the brain probably ensues upon inadequate collateral circulation of these vessels, whether due to a pathological or to a traumatic condition. Recently it has been shown that there are special systems of nutrient arteries derived from the circle of Willis, the *central* or *ganglionic* and the *peripheral* or *cortical arteries.* These systems are independent of each other, and their *terminal arteries* (*of Cohnheim*) do not anastomose.

The most noteworthy group of vessels of the ganglionic system are the branches from the middle cerebral artery which penetrate the anterior perforated space to supply the corpus striatum and optic thalamus on each side. A particular branch, the *lenticulo-striate artery,* so called because of its distribution to the lenticular and caudate nuclei, is often the source of cerebral hemorrhage. The cortical arteries are peculiar in their mode of origin, being adapted to the immediate supply of blood to the brain-tissue. They arise directly from the larger arteries in minute branches, which take a vertical or an oblique course, according to their destination,

those on the upper border of a convolution being vertical, and those on the sides passing obliquely. Those which penetrate the layers of cortical gray matter to the centrum ovale are the *medullary capillaries*, and vary from three to five centimetres, or from one to two inches, in length. These are the terminal arteries proper. In consequence of the independence of these cerebral capillary systems, many localized lesions, arising from emboli obstructing the blood-current, can be recognized and explained during life. Such a lesion may be limited to an area involving a special function, especially in the region supplied by the branches of the middle cerebral artery,—*i.e.*, the motor centres and the faculty of speech.

As elsewhere in the body, the principal vessels are supplied with *sympathetic nerves*, and these form in the head intricate plexuses mainly around the internal carotid arteries at the base of the brain.

After removal of the pia mater, the brain-mass, with its furrows and convolutions, is exposed directly to view (Plate 10, Fig. 2). If the organ is retained within the skull, the proper relations which the surface-markings of the brain bear to the overlying structures can be profitably studied; and, as the subject of *cranio-cerebral topography* has now attained great importance, owing to the recent development of intra-cranial surgery, it will receive especial attention.

In order that a clearer comprehension of this difficult and complex region may be obtained, a succinct description of the surface anatomy of the brain removed from the head will be given before explaining its application.

The brain (encephalon) is that portion of the central nervous system which is contained within the cranium, and consists of the cerebrum, cerebellum, pons, and medulla oblongata. The cerebrum overlies the other portions of the brain, occupying the whole of the upper part of the cranial cavity. Its base rests on the anterior and middle fossæ of the skull, and posteriorly it is separated from the cerebellum by the *tentorium*, the arching transverse fold of the dura mater. The cerebellum occupies the occipital fossæ. The pons (Varolii) rests upon the basilar process and body of the sphenoid bone, and is connected with the cerebrum by the crura cerebri, and with the cerebellum by the crura cerebelli. The

medulla oblongata is the portion below the pons, and rests upon the basilar process of the occipital bone. It is continuous with the spinal cord.

The brain conforms in size and shape with the interior of the skull, or brain-case. Its mass is to some extent related to the size of the body, and it is modified by the degree of mental development of the individual to whom it belongs, the intelligence probably depending upon the quality rather than upon the quantity of the organ. During intra-uterine life the *development of the brain* is very active, and at birth it is relatively of large size, of a soft pulpy consistence, presenting an approximation in form and relations to the adult brain. It grows rapidly up to the seventh year, becoming gradually firmer, and from that period until about the age of forty it increases very slowly. Its full growth is considered to have been attained between forty-five and fifty years of age. The average weight of the brain in males is forty-nine ounces; in females, forty-four ounces. In old age it decreases in a measure commensurate with the waning of the faculties. The brain consists of gray and white neural tissue variously disposed, the gray matter, composed mainly of *nerve-cells*, being arranged on the cortical surface, and in the ganglionic masses at the base of the organ; the white matter, made up of *nerve-fibres*, being within, and serving to connect the gray portions and to bring them into relation with the spinal cord through the pons and medulla. The gray matter on the cortical surface is arranged in several layers of various forms of cells, which are intimately surrounded with numberless capillary vessels from the adjacent pia mater. These cells are connected through their prolongations with the nerve-fibres of the white substance. The minute structure of the nerve-cells and nerve-fibres is described with the anatomy of the spinal cord in Vol. II.

The whole brain is partially divided into symmetrical halves by a median fissure extending from before backward. The *area of the surface of the brain* is greatly extended by the cortical gray matter being irregularly raised in tortuous convolutions (*gyri*) or involuted into furrows (*sulci*), so that, with great economy of space, its actual surface is nearly six times what it would be were it merely a smooth envelope. The number of convolutions and the depth of the furrows between them

vary in different brains, and consequently the extent of the gray surface-matter upon which the intellectual capacity depends is variable.

All physical and moral actions have their perceptive centres somewhere in the cortical substance of the cerebrum. An animal may live after removal of its cerebral hemispheres, but it will be insensible to peripheral disturbance and incapable of exercising volition. The anterior portions of the hemispheres are without sensibility, as is manifest in cases of wounds in which they have been injured.

The cerebrum consists chiefly of two lateral masses, called, from their shape, *hemispheres*, which are partially separated by the falx cerebri of the dura mater being received into the great longitudinal fissure between them. At the bottom of this fissure a band of white transverse nerve-tissue connects the two hemispheres: this band, owing to the decussation of its component fibres, is known as the *commissure of the cerebrum*, or the *corpus callosum* (Plate 11, Fig. 1, No. 8).

The hemispheres are not always of equal size, as the longitudinal fissure is not always placed exactly in the middle line (Plate 6, Fig. 1). The left hemisphere has generally been found to be larger than the right, and this has been attributed to the more direct blood-supply to the brain on that side, through the left vertebral and common carotid arteries, the latter arising independently from the arch of the aorta. The right hemisphere is often, however, larger than the left (Plate 6, Fig. 1) in a brain otherwise normally developed. Each hemisphere consists of an *anterior* (*frontal*), a *middle* (*temporo-sphenoidal*), and a *posterior* (*occipital*) *lobe*, which are best seen on the under surface, and correspond to their respective positions in the fossæ of the cranium. Besides these there are the *parietal lobe*, placed between the *frontal* and the *occipital lobe*, on the lateral and upper surface, and the *central lobe*, situated within the fissure of Sylvius, at the base of the brain.

The disposition of the convolutions and furrows on the surfaces of the two hemispheres is not identical, owing to the varying development of the several localities. It is, therefore, improbable that any definite area will always possess the same group of nerve-cells, for they may be on the surface of a convolution in one brain, and in an adjacent furrow

in another, depending upon the relative growth of the locality. The *primary fissures* of the cerebral hemispheres—viz., the Sylvian, hippocampal, parieto-occipital, and calcarine—appear during the third month of fœtal life. The *secondary fissures*, the most important being the fissure of Rolando, appear between the fifth and sixth months. The further development of the fissures, and consequently of the convolutions, occupies the last two months of fœtal life and the first five or six weeks after birth, at which time the cerebral surface can be clearly mapped out. The largest and most complicated convolutions characteristic of the *human* brain are upon the *upper* surface of the hemispheres, frequently branching toward the longitudinal fissure in their course like the letter **Y**. They do not exactly correspond upon the two sides. The most important of the convolutions on the external surface of the hemispheres are the central, or parietal, convolutions, which are always the most perfectly developed in all animals whose brains are convoluted. They occupy approximately the same relative position on each side of the brain, and are separated by the deep fissure of Rolando or central fissure (Plates 6 and 7). The area surrounding this fissure has been satisfactorily proved by physiological research and pathological facts to involve the principal motor functions of the body (Plate 2, Fig. 2, and Plate 10, Fig. 2).

The *fissure of Rolando* (Plate 6, Fig. 1, Nos. 3 and 13, and Plate 7, Figs. 1 and 2, No. 1) usually begins close to the longitudinal fissure, about its middle, on the upper surface, and runs obliquely over the outer convex surface of the hemisphere downward and forward, until within a short distance of the fork of the *Sylvian fissure*. The lesser wing of the sphenoid bone is lodged within the fissure of Sylvius. This fissure begins (Plate 6, Fig. 2, No. 6) in a depression called the *vallecula*, at the anterior perforated space at the base of the cerebrum, and passes outward as a deep cleft (Plate 7, Fig. 1, No. 22), which divides into an ascending or *vertical* branch two centimetres, or a little less than an inch, in length, and a *horizontal* branch, which passes backward and curves slightly upward. It usually terminates in the parietal lobe in a *bifid* extremity. At the point where these branches originate, a third branch passes transversely, and is hidden within the substance of the brain. The branches

PLATE 4.

Figure 1.

The right hemisphere of the cerebrum removed to show the falx cerebri and tentorium of the dura mater, and the relations of the great sinuses and their tributaries. (From the same head as in Plates 9 and 10.)

1. The cut tissues of the scalp.
2. The outer table of the skull-cap.
3. The diploic structure.
4. The inner table of the skull-cap.
5. The superior longitudinal sinus.
6. The inferior longitudinal sinus.
7. The falx cerebri.
8. One of the posterior tributary veins.
9. The venæ Galeni.
10. The straight sinus.
11. The tentorium cerebelli.
12. The position of the torcular Herophili.
13. One of the anterior tributary veins.
14. The convolution of the corpus callosum of the left hemisphere.
15. The apex of the longitudinal sinus passing to the foramen cæcum.
16. The artery of the corpus callosum.
17. The crista galli of the ethmoid bone.
18. The corpus callosum.

Figure 2.

The posterior third of the skull and its scalp removed to show the posterior view of the dura mater, and the confluence of the lateral and occipital sinuses with the superior longitudinal sinus. Also the posterior segments of the cervical vertebræ are removed to show the continuation of the dura mater of the brain with that of the spinal cord, the ganglions on the posterior roots of the cervical nerves, and the course of the vertebral arteries through the vertebral foramina.

1. The cut tissues of the scalp.
2. The section of the parietal bones at the sagittal suture.
3. The dura mater over the posterior lobe of the left hemisphere of the cerebrum.
4. The great, or superior, longitudinal sinus.
5. The posterior branches of the left middle meningeal artery.
6. The left lateral sinus.
7. The left occipital sinus.
8. The left sub-occipital (or first cervical nerve).
9. The left vertebral artery curving upon itself before entering the foramen magnum.
10. The ganglion on the posterior root of the second cervical nerve.
11. The left transverse process of the atlas vertebra.
12. The descending branch of the posterior division of the second cervical nerve, passing to the third.
13. The ganglion on the posterior root of the third cervical nerve.
14. The left internal jugular vein.
15. The left common carotid artery.
16. The ganglion on the posterior root of the fourth cervical nerve.
17. The left sterno-cleido mastoid muscle.
18. The ganglion on the posterior root of the fifth cervical nerve.
19. The left brachial plexus of nerves.
20. The posterior branches of the right middle meningeal artery.
21. The right lateral sinus.
22. The right occipital sinus.
23. The right posterior meningeal artery.
24. The right sub-occipital (or first cervical nerve).
25. The right vertebral artery at its curvature.
26. The occipitalis major nerve (or internal branch of the posterior division of the second cervical nerve).
27. The right spinal accessory nerve.
28. The descending branch of the second cervical nerve.
29. The right common carotid artery.
30. The ganglion on the posterior root of the third cervical nerve.
31. The right internal jugular vein.
32. The right vertebral artery.
33. The dura mater of the spinal cord.
34. The right fourth cervical nerve.
35. The right fifth cervical nerve.
36. The right brachial plexus.

Fig. 1

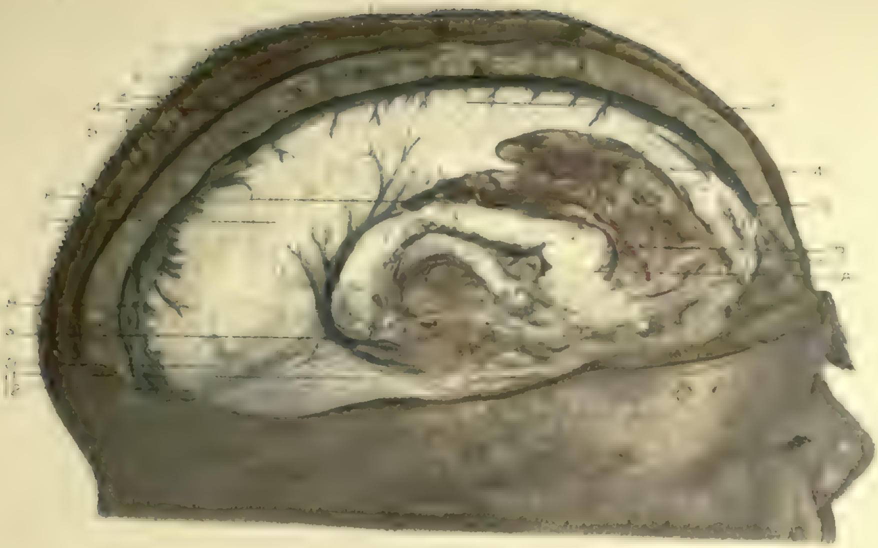
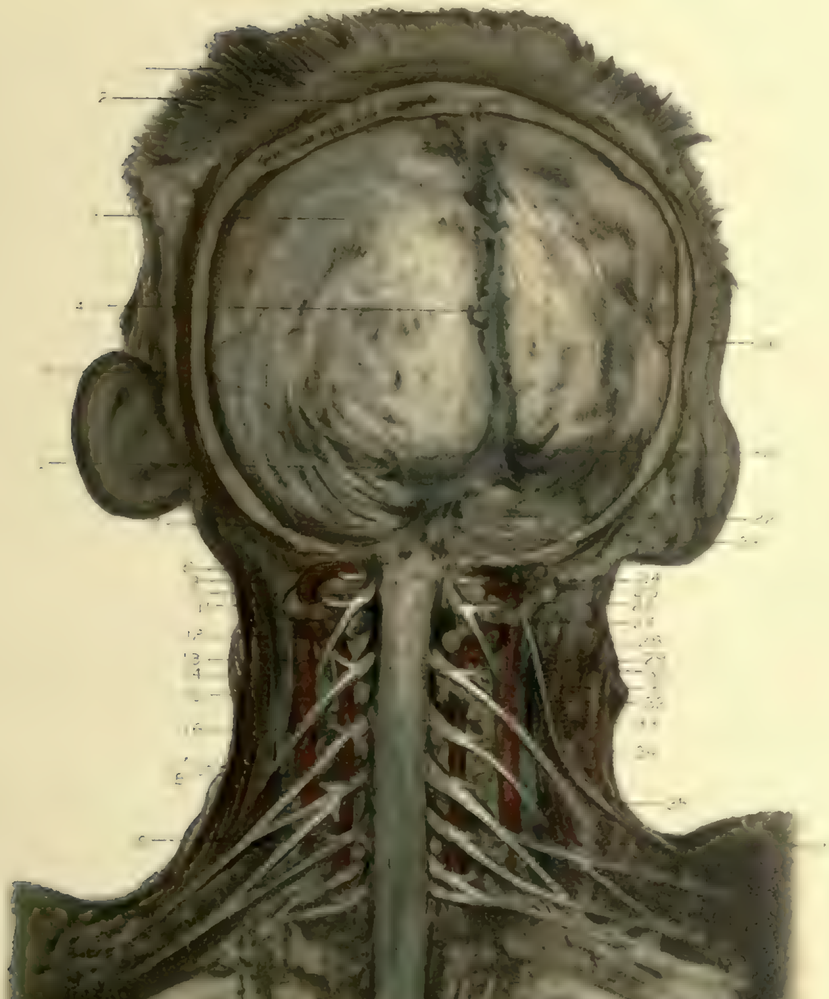


Fig. 2



of the fissure of Sylvius originate from the development of the hemisphere around the *central lobe* (or *insula*), which is usually covered in (Plate 7, Fig. 1), but is occasionally visible (Plate 7, Fig. 2, No. 7). The portion of the hemisphere overlapping the central lobe is called the *operculum*, from its lid-like character. The fissure of Sylvius is the most conspicuous of the cerebral fissures, and is easily recognizable. The *parieto-occipital fissure* is seen on the median surface (Plate 8, Fig. 1, No. 5, and Fig. 2, No. 20). It begins at the calcarine fissure near the corpus callosum, and ascends vertically, ending on the external surface, about an inch beyond the longitudinal fissure. It partially defines the parietal and occipital lobes, and occasionally blends with the horizontal branch of the Sylvian fissure. The *calcarine fissure* (Plate 8, Fig. 1, No. 7, and Fig. 2, No. 23) begins near the posterior border of the hemisphere and passes forward, receiving the parieto-occipital fissure midway, and ends under the corpus callosum, penetrating into the posterior horn of the lateral ventricle, dividing the hippocampal convolution.

The *hippocampal fissure* extends from the gyrus fornicatus to the hippocampal hook. The *fascia dentata* projects inwardly through this fissure, over which the *pia mater* passes to join with the choroid plexus of the lateral ventricle.

The *transverse fissure* (*of Bichat*) is the breach between the cerebrum and the cerebellum (Plate 7, Fig. 1, No. 12). This fissure is due to the cerebral hemispheres being folded backward over the thalamic region, and it admits the pia mater into the interior of the brain as the velum interpositum.

The *interparietal fissure* (Plate 7, Fig. 1, No. 5, and Fig. 2, No. 20) is the most important of the secondary furrows on the parietal portion of the hemisphere. It is very variable in form and position, sometimes being connected with the parieto-occipital and sometimes with the horizontal branch of the Sylvian fissure. Generally it begins between the latter and the Rolandian fissure, and curves backward somewhat parallel with the superior border of the cerebrum.

It will be noticed that the character of nearly all the great fissures which separate the cortical surface into lobes is variable. This is even

more so with regard to the smaller (*intra-lobular*) fissures between the convolutions in the different lobes of the hemispheres. The changes in the position of these furrows probably depend upon the variability of the development of their localities in different brains.

The *frontal lobe* (Plate 6, Fig. 1, No. 2) consists of the cerebral surface situated in front of the fissure of Rolando and over the fissure of Sylvius. This lobe is divided by furrows (the *frontal sulci*) into four principal convolutions (the *frontal gyri*), which are subdivided into secondary convolutions by modifications of their arrangement and connections. The frontal convolutions are the superior, middle, and inferior, and the anterior central (Plate 7, Fig. 2, Nos. 2, 3, 4, and 5). The *superior frontal convolution* (Plate 7, Fig. 1, No. 15) is in relation to the longitudinal fissure, borders on the anterior part of the corpus callosum internally, and extends to the under surface, where it is known as the *olfactory convolution*, from its reception of the olfactory bulb in a depression (Plate 6, Fig. 2, No. 2). The adjacent *middle frontal convolution* (Plate 7, Fig. 1, No. 17) also extends to the under surface, and is there called the *orbital convolution*. The *inferior frontal convolution* (Plate 7, Fig. 1, No. 19) is below the preceding and in relation to the Sylvian fissure. It is now often called *Broca's convolution*, or the *speech centre*, from the localization of the movements of the lips and tongue, in articulation, in its posterior portion.

The *anterior central* or *ascending frontal convolution* (Plate 7, Fig. 1, No. 14) is separated from the three frontal convolutions by the posterior frontal (or *vertical*) furrow (Plate 7, Fig. 1, No. 16), and it usually blends with the upper and lower frontal convolutions, and with the posterior central convolution, curving round the ends of the *central fissure* of Rolando.

The *parietal lobe* occupies the upper and lateral portions of the hemisphere between the fissure of Rolando and the external part of the parieto-occipital fissure, and is over the horizontal branch of the fissure of Sylvius. There are three principal convolutions on the outer surface of this lobe,—the posterior central and the superior and inferior parietal convolutions.

The *posterior central* or *ascending parietal convolution* is, as before stated, ordinarily continuous with the anterior central or ascending frontal. The two convolutions thus completely surround the fissure of Rolando (on the cortical surface), and the area thus formed is called the *opercular lobe* (Plates 6 and 7). The connecting portion above the fissure of Rolando is the *para-central lobule,* and that below it is the *infra-central lobule.* The latter region is considered to be correlated with the movements of the head and face, while those of the arm and hand are referred to the middle portions of the anterior and posterior central convolutions, and those of the leg and foot to the para-central region.

The *superior* and *inferior parietal convolutions* are separated by the inter-parietal fissure (Plate 7, Fig. 2, No. 20), and are usually continuous with the convolutions of the occipital lobe by bridges of gray matter called the *annectent convolutions.*

Both of the parietal convolutions are variously subdivided. The *inferior* is very tortuous, and commonly consists of two chief portions, the *superior marginal* and the *angular convolution.* The former usually blends with the lower part of the posterior central convolution and arches over the end of the horizontal branch of the Sylvian fissure to join the superior temporal convolution. The *angular convolution* (Plate 7, Fig. 1, No. 7) is behind the supra-marginal and parallel with the Sylvian fissure. It usually joins the middle temporal convolution by means of the two lower annectent convolutions. Upon the median surface the superior parietal convolution joins with the upper extremity of the posterior central convolution to form the *præcuneus,* or *quadrate lobule* (Plate 8, Fig. 2, No. 18), which is continuous with the convolution of the corpus callosum.

The *occipital lobe,* also variously subdivided, presents three principal convolutions, superior, middle, and inferior, which are subdivided by the occipital fissures and continuous with the convolutions of the parietal and temporal lobes. Upon the median surface the superior occipital convolution, somewhat triangular in shape, forms the *cuneus lobule,* placed between the parieto-occipital fissure and the calcarine fissure.

The surface of the occipital lobe which rests upon the tentorium is composed chiefly of two convolutions, the inner one of which blends with

the hippocampal convolution and the outer one is the occipital part of the *occipito-temporal convolution.* They are both continuous with the convolutions on the under surface of the temporal lobe. The *temporal lobe* (*temporo-sphenoidal*) presents on its outer surface generally three defined convolutions, superior, middle, and inferior, separated by variously arranged temporal fissures, and connected, as above stated, with the parietal and occipital convolutions.

The *hippocampal convolution* is separated from the occipito-temporal convolution, on the under surface, by the *collateral fissure.* It forms the floor of the middle horn of the lateral ventricle, terminating in the *hippocampal hook* (*processus unciformis*). The calcarine fissure divides the hippocampal convolution at the back part of the corpus callosum.

The *central lobe, island of Reil*, or *insula*, as it is variously known, is situated within the fork of the Sylvian fissure, where it is occasionally partially visible on the external surface (Plate 7, Fig. 2, No. 7), and is overlapped by the operculum. It consists of from four to six small convolutions (the *gyri operti*), arranged side by side upon a triangular mass, and appearing, when exposed, very much like the fingers of the hand when closed upon the palm. These convolutions are the first to appear in the fœtus and among animals, and are gradually enclosed by the other principal convolutions developing around them.

Behind the central lobe there are usually several small convolutions, known as the *temporo-parietal* or *retro-insular convolutions.* They bridge over the temporal and parietal lobes. The *fornicate convolution*, or *convolution of the corpus callosum*, which is to be seen on the median surface (Plate 8, Fig. 1, No. 16), extends round the upper surface of the corpus callosum, beginning at the anterior perforated space, and blending behind with the uncinate convolution below the quadrate lobule.

Cranio-Cerebral Topography.—In the description of the landmarks of the head the relations which the external parts of the cranium bear to the surface-coverings are stated in detail. The topographical survey of the skull is here considered in its relation to the brain (Plate 9, Fig. 1).

The points on the outer surface of the calvarium which bear upon

the position of the principal fissures of the brain cannot always be definitely determined through the scalp, even though the head be shaved; and the most careful observation, or calculation based on statistics of measurements, cannot insure accuracy, for no two heads are precisely alike in their conformation and the arrangement of their contents.

Only *approximative* results can be obtained by deducing from the landmarks of any skull the relative positions of the parts of the brain which it contains. A line drawn across the forehead above the eyebrows in front, and along the side of the head, two centimetres, or a finger's breadth, above the external angular process of the orbit, to the root of the zygomatic process and thence to the external occipital protuberance, corresponds in a measure to the *lower level of the cerebrum* (Plate 2, Fig. 1); the cerebellum occupies the space below the latter portion of this line, but its lower level cannot be defined externally, as it depends upon the extent to which the lower occipital fossæ project at the nape of the neck. The *frontal* and *parietal eminences* seem to indicate the proportionate development of the frontal and parietal lobes of the cerebrum. The parietal eminence corresponds to the supra-marginal convolution, and the frontal eminence to the superior frontal convolution. The *pterion* is the junction of the great wing of the sphenoid bone with the frontal, parietal, and temporal bones. Here the *fissure of Sylvius* commences. Its short ascending branch is just behind and parallel with the coronal suture, and its long horizontal branch extends upward and backward across the upper margin of the squamo-parietal suture on a line drawn on the side of the head from the nasion to the lambda (Plate 2, Fig. 2, No. 6, and Plate 53, Fig. 1, No. 18). The coronal suture passes from the *bregma,* the junction of the coronal and sagittal sutures, at the top of the head, to the middle of the zygomatic arch. The *lambda* is the junction of the sagittal and lambdoid sutures. The external portion of the parieto-occipital fissure is a little in front of the lambda. The *inion* is the external occipital protuberance. The upper end of the *fissure of Rolando* (Plate 2, Fig. 2, No. 13) begins at or near the middle line five centimetres, or about two inches, behind the coronal suture, or at a point one centimetre, or about half an inch, back from the middle of

PLATE 5.

Figure 1.

The pia mater, with its vessels ramifying over the convolutions on the upper surface of the hemispheres. The longitudinal sinus in position, with clusters of the Pacchionian granules within it and upon either side.

1. The frontal sinus of the skull.
2. The forepart of the longitudinal sinus passing towards the foramen cæcum.
3. The Pacchionian granules in relation to the left side of the longitudinal sinus.
4. The longitudinal sinus of the dura mater.
5. The vessels of the pia mater over the left hemisphere.
6. The longitudinal sinus passing backward to the torcular Herophili.
7. The Pacchionian granules in relation to the right side of the longitudinal sinus.
8. The vessels of the pia mater over the right hemisphere.

Figure 2.

The base of the skull with the cerebellum retained in the occipital fossæ. Portions of the orbital roofs are removed to show the nerves and muscles passing to the eyeballs.

1. The frontal branch of the left ophthalmic nerve.
2. The left supra-trochlear nerve.
3. The left eyeball.
4. The left superior rectus muscle.
5. The nasal branch of the left ophthalmic nerve.
6. The fatty capsule of Tenon.
7. The left external rectus muscle.
8. The left optic nerve, passing into the optic foramen.
9. The left internal carotid artery.
10. The optic commissure.
11. The nerve to the left superior oblique muscle (or fourth cranial nerve).
12. The Gasserian ganglion of the left fifth cranial nerve.
13. The cut end of the left abducent nerve to the external rectus muscle.
14. The left lobe of the cerebellum, showing the superior cerebellar veins.
15. The right eyeball.
16. The right external rectus muscle.
17. The frontal branch of the right ophthalmic nerve.
18. The right superior rectus muscle.
19. The nasal branch of the right ophthalmic nerve.
20. The capsule of Tenon.
21. The right optic nerve.
22. The right internal carotid artery.
23. The pituitary fossa.
24. The nerve to the right superior oblique muscle (or fourth cranial nerve).
25. The Gasserian ganglion of the right fifth cranial nerve.
26. Section through the pons Varolii.
27. The right lobe of the cerebellum.

Figure 3.

The base of the brain, showing the anastomosis of the arteries, called the circle of Willis. (From an adult male.)

1. The arteries of the corpus callosum within the longitudinal fissure.
2. The arteries to the right frontal convolutions.
3. The right anterior cerebral artery.
4. The right fissure of Sylvius.
5. The anterior communicating artery.
6. The optic commissure.
7. The cut end of the right internal carotid artery.
8. The right posterior communicating artery.
9. The right posterior cerebral artery.
10. The basilar artery, resting on the median groove of the pons Varolii.
11. The right superior cerebellar artery.
12. The right inferior cerebellar artery.
13. The right vertebral artery.
14. The anterior spinal artery.
15. The posterior inferior cerebellar artery.
16. The arteries to the left frontal lobe.
17. The left anterior cerebral artery.
18. The middle cerebral artery, within the fissure of Sylvius, which is displayed by separation of the frontal and parietal lobes.
19. The cut end of the left internal carotid artery.
20. The pituitary body (in this case unusually large).
21. The left corpus albicans.
22. The left posterior communicating artery.
23. The left posterior cerebral artery.
24. The left auditory artery.
25. The left posterior cerebellar artery.
26. The left vertebral artery.
27. The medulla oblongata.
28. The external branches of the left posterior cerebellar artery.

PLATE 5.

Figure 1.

The pia mater, with its vessels [illegible] the hemispheres. The longitudinal [illegible]

1. [illegible]
2. [illegible]
3. [illegible]
4. The [illegible]
5. The vessels of the [illegible]
6. The longitudinal [illegible]
7. [illegible]
8. [illegible]

Figure 2.

The base of the skull with the cerebellum retained in the occipital fossæ. Portions of the orbital roofs are removed to show the nerves and muscles passing to the eyeballs.

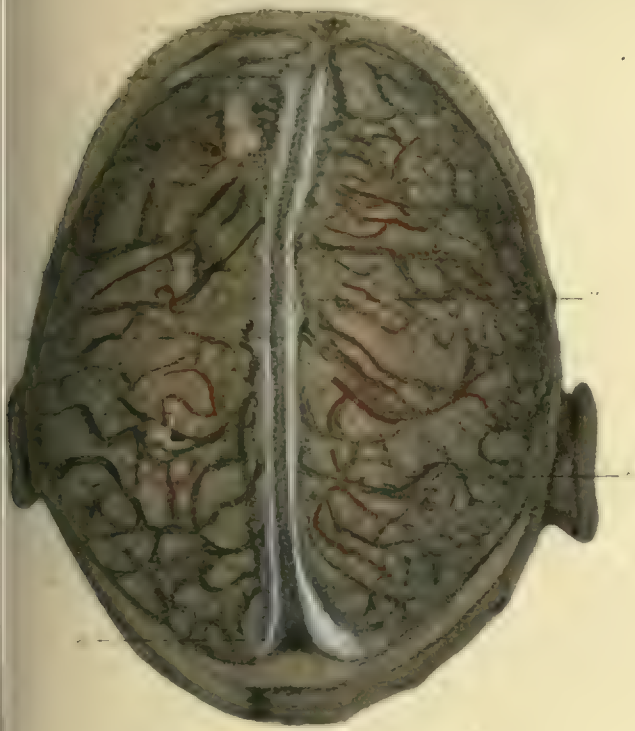
1. The frontal branch of the left ophthalmic nerve.
2. The left [illegible] nerve.
3. The left [illegible]
4. The left [illegible] rectus muscle.
5. The nasal branch of the left ophthalmic nerve.
6. The fatty [illegible]
7. The left external rectus muscle.
8. The left optic nerve passing into the optic foramen.
9. The left internal carotid artery.
10. The optic commissure.
11. The nerve to the left superior oblique muscle (or fourth cranial nerve).
12. The Gasserian ganglion of the left fifth cranial nerve.
13. The cut end of the left abducent nerve to the external rectus muscle.
14. The left lobe of the cerebellum, showing the superior [illegible]
15. The right eyeball.
16. The right external rectus muscle.
17. The frontal branch of the right ophthalmic nerve.
18. The right [illegible]
19. The nasal branch of the right [illegible]
20. [illegible]
21. [illegible]
22. [illegible]
23. [illegible]
24. The nerve to the right superior oblique muscle (or [illegible])
25. The Gasserian ganglion of the right fifth cranial nerve.
26. [illegible]
27. [illegible]

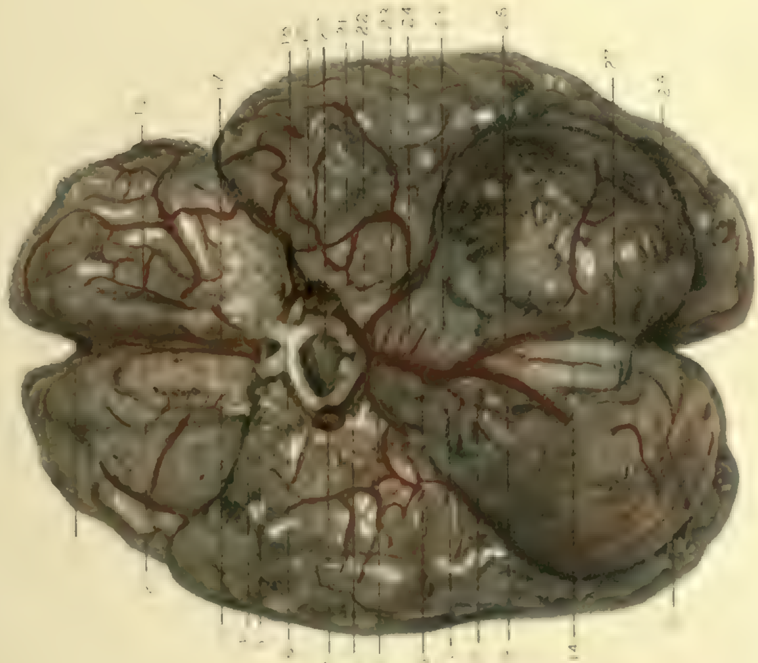
Figure 3.

The base of the brain, showing the anastomosis of the arteries, called the circle of Willis. (From an adult male.)

1. The arteries of the corpus callosum within the longitudinal fissure.
2. The arteries to the right frontal convolutions.
3. The right anterior cerebral artery.
4. The [illegible] fissure of Sylvius.
5. The anterior communicating artery.
6. [illegible]
7. The cut end of the right internal carotid artery.
8. The right posterior communicating artery.
9. The right posterior cerebral artery.
10. The basilar artery, resting on the median groove of the pons Varolii.
11. The right [illegible]
12. The right [illegible]
13. The [illegible] vertebral artery.
14. [illegible] artery.
15. The posterior inferior cerebellar artery.
16. The arteries to the left frontal lobe.
17. The left anterior cerebral artery.
18. The middle cerebral artery, within the fissure of Sylvius, which is [illegible] of the [illegible] and [illegible]
19. [illegible] artery.
20. [illegible]).
21. [illegible]
22. The left posterior [illegible] artery.
23. The left posterior cerebral artery.
24. The [illegible] auditory [illegible]
25. The left [illegible]
26. [illegible]
27. [illegible]
28. [illegible] of the left posterior [illegible] cerebellar artery.

Fig I





the distance from the *ophryon*, or glabella, to the inion. This fissure passes obliquely downward toward the horizontal branch of the fissure of Sylvius, and its lower end is two and one-half centimetres, or about one inch, behind the coronal suture where it joins the other bones to form the pterion. The *posterior frontal sulcus* (or furrow) is just behind and parallel with the coronal suture (Plate 2, Fig. 2, No. 4). It is sometimes called the vertical sulcus. The ascending frontal convolution is between the posterior frontal sulcus and the fissure of Rolando.

The upper end of the posterior frontal sulcus reaches to about the middle of the fissure of Rolando. The *inferior frontal sulcus* branches off from it about on a level with the *superior stephanion*, which is the point of intersection of the coronal suture and the ridge for the temporal fascia (Plate 2, Fig. 1, No. 5). The *superior frontal sulcus* begins in the upper part of the ascending frontal convolution, over the posterior frontal sulcus, and passes forward and parallel with the inferior. The lower end of the inferior frontal sulcus is separated from the fissure of Sylvius by the *operculum*. The *inter-parietal sulcus* is behind the fissure of Rolando and parallel with the great longitudinal fissure between the hemispheres. It is midway between the latter and the parietal eminence (Plate 2, Fig. 1, No. 12). The *basion* is the middle of the anterior border of the foramen magnum at the base of the skull.

The convolutions in the various regions are designated according to their positions, and their relations are mapped out when the positions of the fissures and sulci are determined.

In seeking to ascertain the function of any locality on the cerebrum, it has been discovered, by means of gentle electrical stimulation, that the so-called *motor cells* are only in the gray matter on the surface, and that faradism of the sides and bottom of the fissures produces no motor reaction.

The area of the *opercular lobe*, which includes the central fissure of Rolando, has been demonstrated to be the controlling centre of the movements of the limbs (Plate 2, Fig. 2, and Plate 10, Fig. 2). This area consists of the following convolutions: the *anterior central* (or *ascending frontal*) *convolution*, in front of the central fissure; the *posterior central*

(or *ascending parietal*) *convolution*, behind the central fissure; the *para-central convolution*, which surmounts the central fissure and extends on the median surface of the hemisphere to the calloso-marginal fissure (Plate 8, Fig. 2, No. 17); and the *infra-central convolution*, which separates the central fissure from the horizontal branch of the fissure of Sylvius. The infra-central convolution is correlated with the movements of the face (mouth, lips, tongue, throat, and larynx). Movements of the fingers are produced by stimulation of the cortical surface in the lower portion of the anterior central convolution, and movements of the thumb by stimulation of the corresponding portion of the posterior central convolution. The centre for the wrist is just above the latter, at about the middle of the central fissure, and that for the elbow and shoulder a little higher. Observation has shown that the centres for the upper extremity embrace the adjacent portions of the convolutions on both sides of the central fissure (Plate 10, Fig. 2). The movements of the hip, knee, leg, foot, and toes are presided over by the para-central convolution and the contiguous parts of the anterior and posterior central convolutions.

The inter-parietal fissure is probably the posterior limit of the motor area.

The frontal lobe of the brain anterior to the motor region seems to be related to the highest processes of the mind. Lesions in this locality are generally followed by proportionate mental deterioration.

The *sensorial area* has not been conclusively determined, but it is believed to include the general surface of the cerebrum posterior to the inter-parietal fissure, limited externally by the parieto-occipital fissure (Plate 7 and Plate 10, Fig. 2) and internally by the calloso-marginal fissure (Plate 8).

The centre for the movements of the eyes and eyelids involves the angular gyrus; while the centre for vision extends from the angular gyrus over the occipital lobe and adjoining portions of the temporal and parietal lobes. The centre for hearing seems to be localized in the first and second temporo-sphenoidal convolutions. The centre for smell is supposed to be established in the hook of the hippocampal convolution, and the centre for taste just below it. The speech-centre has already been mentioned

in the description of the inferior frontal convolution (page 30). It is posterior to the fork of the fissure of Sylvius.

The function of the island of Reil, or central lobe, is not determined, but, from its development, its position, and its relation to the other lobes of the brain as well as the basal ganglia, it probably plays an important *rôle* in the association of their related functions.

During life the vessels of the pia mater are engorged with blood, especially if the patient has been under the influence of alcohol or an anæsthetic, and the subjacent cerebral fissures and sulci are indistinguishable through an opening in the skull. All that is possible, therefore, is to conjecture or infer what portion of the cortical surface of the brain is at the bottom of a hole made by the trephine (Plate 50, Fig. 1).

That the results of operative interference with the brain-structure should so often verify diagnosis is cause for wonder, when one considers the uncertain features of the anatomy of localization (Plates 9 and 10). Repeated examinations of the relations of the fissures to carefully mapped-out points after removal of a disk of bone on the heads of many cadavers have shown the author the fallacy of depending solely upon measurements, and the importance of making the artificial opening in the skull large enough to enable the operator to see the parts exposed.

The base of the cerebrum is subdivided, as already described, into anterior, middle, and posterior lobes for each hemisphere. The posterior lobes are separated from the cerebellum by the tentorium of the dura mater.

When the entire brain is removed from the calvarium and its *under surface* (Plate 6, Fig. 2) examined, the arrangement of the objects brought to view can be best studied by commencing in front. The *longitudinal fissure*, approximately in the middle line, separates the frontal lobes. Within the longitudinal fissure is the transverse commissure, or *corpus callosum*, from which white bands pass backward on each side to the fissure of Sylvius. They are called the *peduncles of the corpus callosum.* The *lamina cinerea* is a thin layer of gray tissue extending from the corpus callosum to the optic commissure. The fissure of Sylvius, between the frontal and middle lobes, lodges the middle cerebral artery,

and the fissure begins in the *vallecula*, which is also known as the *anterior perforated space*, because it is perforated by the vessels which supply the corpus striatum. This anterior perforated space is the apparent origin of the three roots of the *first cranial nerves* (or *olfactory bulbs*) (Plate 6, Fig. 2), on each side. Each olfactory bulb is received into a straight furrow on the orbital surface of the frontal lobe and lies on the cribriform plate of the ethmoid bone (Plate 3, Fig. 1, No. 1). The outer white root of the olfactory bulb originates in a nucleus of gray matter in the anterior part of the middle lobe of the hemisphere, and from the fissure of Sylvius passes along the outer side of the anterior perforated space. The middle gray root takes origin from the anterior perforated space and the furrow in which it rests on the frontal lobe. The inner white root arises from the gyrus fornicatus on the median surface of the hemisphere. The olfactory bulbs are in reality the prolongations of the frontal portions of the cerebral substance. On their under surface, as they rest on the cribriform plate of the ethmoid bone, they give off about twenty nerves, which are distributed to the nasal mucous membrane (page 116). Behind the lamina cinerea is the *optic commissure*, formed by the union of the *optic tracts*, which arise from the anterior lobes (*nates*) of the corpora quadrigemina, the corpora geniculata, and the posterior portions of the optic thalami, winding round the crura cerebri.

In the skull the optic commissure rests upon the olivary process of the sphenoid bone, and from it the *second cranial nerves* (or *optic*), surrounded by prolongations of the dura mater, pass into the orbits through the optic foramina and enter the back of the eyeballs (Plate 5, Fig. 2, Nos. 8 and 21), eventually expanding into the retinæ. The ophthalmic arteries accompany the optic nerves through the optic foramina. The commissure consists of lateral fibres which pass from one optic tract to the optic nerve of the same side, anterior fibres which pass from one optic nerve to the other optic nerve, posterior fibres which pass from one optic tract to the other optic tract, and middle decussating fibres which cross from the optic nerve of one side to the optic tract of the other side.

The *tuber cinereum* is the gray prominence behind the optic commissure. This prominence is the floor of the third ventricle of the brain,

and from it is projected a red-colored conical tube, the *infundibulum*, to which is attached the *pituitary body* (Plate 5, Fig. 3, No. 20). The pituitary body is lodged in the *sella turcica* of the sphenoid bone (Plate 12, No. 27), and is difficult to retain in removing the brain from the skull. It consists of two lobes, the posterior one being originally a prolongation downward of the cavity of the third ventricle through the infundibulum. Usually in later life the cavity in the posterior lobe of the pituitary body is obliterated. Behind the tuber cinereum are the *corpora albicantia* (Plate 6, Fig. 2, No. 34), which are formed by the bulbs of the fornix, the fibres of which pass downward, and then, after twisting in a figure-of-eight manner, pass upward to end in the optic thalami (Plate 8, Fig. 2, No. 11). Posterior to the corpora albicantia is a gray depression perforated by vessels which supply the optic thalami: it is called the *posterior perforated space*. It is placed between the diverging crura cerebri and in front of the pons Varolii. The *crura cerebri* consist of longitudinal fibres from the pons Varolii and upper part of the medulla oblongata, which pass forward and outward to the middle lobes of the hemispheres (Plate 6, Fig. 2). Division of one of the crura will exhibit in its middle some dark-colored tissue, called the *locus niger*, which separates the crus into two layers of fibres. The lower layer (the *crusta*) consists of coarse fibres arising from the anterior portion of the medulla and the pons. The upper layer (the *tegmentum*) is composed of fine fibres from the lateral portions of the medulla oblongata and also from the corresponding crus of the cerebellum. The lower fibres of each crus cerebri pass chiefly through the corpora striata, and the upper fibres through the optic thalami. In their passage through the ganglionic masses the fibres are greatly augmented, and, branching out, are distributed to the cortical substance on the surface of the hemispheres.

The *third cranial nerves* (or *oculo-motor*) appear just in front of the pons Varolii, issuing from among the fibres on the inner sides of the crura cerebri (Plate 6, Fig. 2, No. 11). These nerves originate from yellow nuclei beneath the passage-way between the third and fourth ventricles (*aqueduct of Sylvius*) (Plate 8, Fig. 1, No. 9), whence they pass forward through the locus niger and tegmentum in each of the crura, and,

after passing through the plexus of veins called the cavernous sinus, in close relation to the internal carotid arteries, enter the orbits by means of the sphenoidal fissures, to be distributed to the muscles of the eye-balls, with the exception of the external recti and the superior oblique.

The *fourth cranial nerves* (or *trochlear*) (Plate 6, Fig. 2, No. 13) wind round the outer sides of the crura cerebri, having each originated from a gray nucleus in the floor of the aqueduct of Sylvius, very near the yellow nuclei of the third nerves. Their fibres decussate in the *roof* of the aqueduct, called the *valve of Vieussens*, about the middle line. They enter the orbit by the sphenoidal fissure and supply the superior oblique muscles (Plate 5, Fig. 2, No. 11).

The *fifth cranial nerves* (or *trifacial*) appear at the base of the brain, each issuing in two separate bundles of fibres from the sides of the pons Varolii near its anterior border (Plate 8, Fig. 2, Nos. 15 and 16). These nerves are the largest of the cranial nerves, and, owing to their complex character and important associations, are of the greatest interest. Each nerve has two distinct *roots*, and therefore resembles a spinal nerve; the anterior root is the smaller, consisting of three or four bundles of fibres, and having *motor* function, and the posterior the larger, composed of from seventy to one hundred bundles of fibres, and possessed of *sensory* function. The motor influences are chiefly confined to the muscles of mastication, while the sensory branches are distributed throughout the head and face (Plate 53, Fig. 1, No. 19). The two roots of this nerve commence in the upper portion of the medulla oblongata, the sensory root originating in the gray tubercle of Rolando, and the motor root from a nucleus of large cells closely connected with the posterior cornu of the medulla wherein the tubercle is situated. On its way forward the motor root receives some fibres from the floor of the fourth ventricle and also from the sides of the aqueduct of Sylvius.

As the two roots issue from the pons Varolii they are separated from each other by a few of the transverse fibres of this body. They proceed forward on the apex of the petrous portion of the temporal bone, where there is a depression (Plate 3, Fig. 5, No. 3) for a semilunar ganglionic enlargement which occurs here upon the sensory root. This is the *Gas-*

serian ganglion (Plate 5, Fig. 2, No. 25), and it furnishes additional resemblance to a spinal nerve, being somewhat similar to the ganglia on their posterior roots (Plate 4, Fig. 2). The motor root passes beneath the ganglion, and has no connection with it,—proceeding independently with the inferior maxillary branch of the sensory root through the foramen ovale, and after its exit at this foramen blending its fibres with those of that nerve. From the anterior border of the Gasserian ganglion three great nerve-trunks are given off,—viz., the *ophthalmic nerve*, which passes through the sphenoidal fissure with the third, fourth, and sixth nerves and the ophthalmic vein, the *superior maxillary nerve*, which passes through the foramen rotundum, and the *inferior maxillary nerve*, which passes through the foramen ovale, by which the lesser meningeal artery (Plate 3, Fig. 2) also enters the skull.

The *sixth cranial nerves* (or *abducent*) emerge between the pons and the anterior pyramids of the medulla oblongata (Plate 6, Fig. 2, No. 17), being connected with both of them. Their deep origins are in the fasciculi teretes in the floor of the fourth ventricle. They leave the skull by the sphenoidal fissures, passing between and supplying the two portions of the external recti muscles of the eyeballs (Plate 5, Fig. 2, No. 13).

The *seventh cranial nerves* (or *facial*) have their deep origins in the floor of the fourth ventricle, whence they pass more superficially than the sixth nerves, and, bending abruptly upon themselves, emerge between the pons and the restiform tract of the medulla oblongata. They enter the internal auditory openings in the temporal bones, and, after passing through the aqueduct of Fallopius (Plate 3, Fig. 5, No. 9) and giving off petrosal branches in their course, pass out by the stylo-mastoid foramina, to be distributed to the facial muscles.

The *eighth cranial nerves* (or *auditory*) also arise from the floor of the fourth ventricle, and are in close relation with the seventh nerves, a connecting link of nerve-tissue (the *pars intermedia* of Wrisberg) being interposed between both of them on each side. On account of this intimate relation, the facial and auditory nerves were formerly classified as two separate portions of the seventh cranial nerve, and because of their difference in character the former was called the *portio dura* and

PLATE 6.

Figure 1.

The upper surface of the brain of a white man about forty-five years of age, in sound condition and normal in general conformation, size, and weight. The right hemisphere is larger than the left, the longitudinal fissure not being in the middle of the cerebral mass. The pia mater has been removed to demonstrate the surface markings.

1. The longitudinal fissure.
2. The left frontal lobe.
3. The left fissure of Rolando.
4. The left parietal lobe.
5. The left calloso-marginal fissure.
6. The left supra-marginal convolution.
7. The left angular convolution (*gyrus*).
8. The left occipital lobe.
9. The right superior frontal convolution.
10. The right middle frontal convolution.
11. The right inferior frontal convolution.
12. The right ascending frontal convolution.
13. The right fissure of Rolando.
14. The right ascending parietal convolution.
15. The end of the horizontal branch of the right fissure of Sylvius.
16. The right parieto-occipital fissure.
17. The right inferior occipital convolution.
18. The right middle occipital convolution.
19. The right superior occipital convolution.

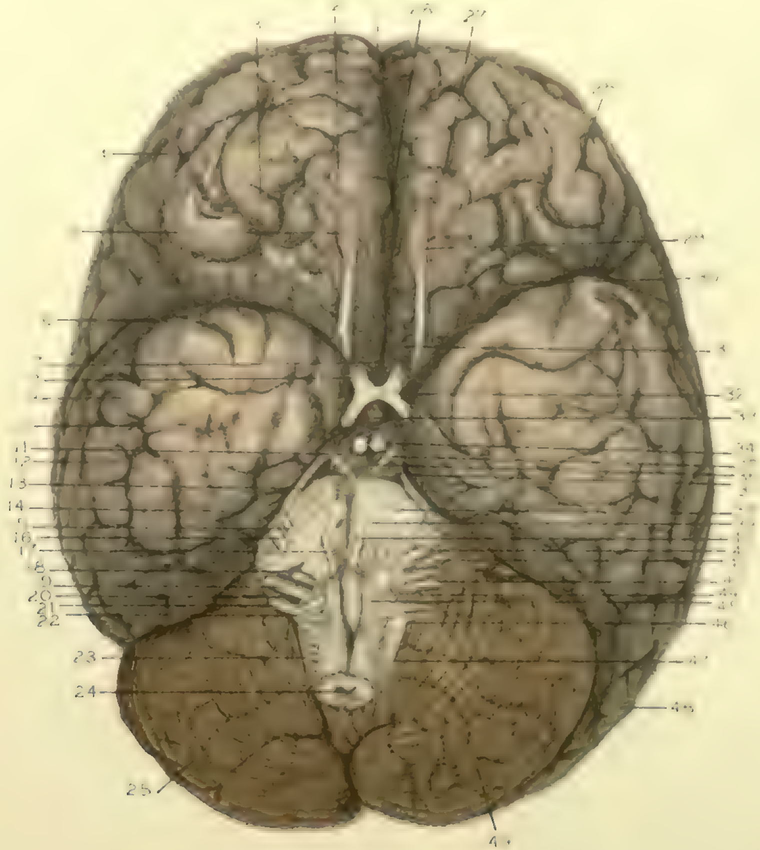
Figure 2.

The under surface of the same brain as in Figure 1, showing the superficial origins of the cranial nerves. The pia mater is removed from the cerebrum, although retained over the cerebellum.

1. The longitudinal fissure.
2. The right olfactory convolution.
3. The right orbital convolution.
4. The right frontal lobe.
5. The right olfactory bulb (or first cranial nerve).
6. The right fissure of Sylvius.
7. The lamina cinerea.
8. The right optic nerve (or second cranial nerve).
9. The right temporo-sphenoidal lobe.
10. The right middle temporo-sphenoidal convolution.
11. The right oculo-motor nerve (or third cranial nerve).
12. The right inferior temporo-sphenoidal convolution.
13. The right trochlear nerve (or fourth cranial nerve).
14. The lobulus fusiformis.
15. The motor root of the right trifacial nerve (or fifth cranial nerve).
16. The sensory root of the trifacial nerve.
17. The right abducent nerve (or sixth cranial nerve).
18. The right facial nerve (or seventh cranial nerve).
19. The right auditory nerve (or eighth cranial nerve).
20. The right glosso-pharyngeal nerve (or ninth cranial nerve).
21. The right pneumogastric nerve (or tenth cranial nerve.)
22. The right hypoglossal nerve (or twelfth cranial nerve).
23. The right spinal accessory nerve (or eleventh cranial nerve).
24. The gray substance of the medulla oblongata.
25. The right lobe of the cerebellum.
26. The left first frontal convolution (*gyrus rectus*).
27. The left middle frontal convolution.
28. The left third frontal convolution.
29. The left olfactory bulb (or first cranial nerve).
30. The left fissure of Sylvius.
31. The anterior perforated space.
32. The optic commissure.
33. The pituitary body.
34. The corpora albicantia.
35. The left oculo-motor nerve (or third cranial nerve).
36. The posterior perforated space.
37. The left trochlear nerve (or fourth cranial nerve).
38. The left trifacial nerve (or fifth cranial nerve).
39. The pons Varolii.
40. The left abducent nerve (or sixth cranial nerve).
41. The left facial nerve (or seventh cranial nerve).
42. The left auditory nerve (or eighth cranial nerve).
43. The left glosso-pharyngeal nerve (or ninth cranial nerve).
44. The left pneumogastric nerve (or tenth cranial nerve).
45. The left olivary body.
46. The left hypoglossal nerve (or twelfth cranial nerve).
47. The left spinal accessory nerve (or eleventh cranial nerve).
48. The left occipital lobe of the cerebrum.
49. The left lobe of the cerebellum.

Fig. 1

Fig. 2



the latter the *portio mollis.* The auditory nerves commence by fibres which originate in the outer and inner auditory nuclei beneath the acoustic tubercles on each side of the floor of the fourth ventricle, and, after receiving some fibres from the transverse striæ in this situation, unite into individual trunks which enter the internal auditory openings of the temporal bones in company with the facial nerves. Within the auditory openings these nerves subdivide into cochlear and vestibular branches, which are distributed to the internal ears (page 78).

The *ninth cranial nerves* (or *glosso-pharyngeal*) appear on the surface of the restiform bodies, below the auditory nerves (Plate 6, Fig. 2, No. 20). The deep origins of these nerves are very close to those of the auditory nerves in the floor of the fourth ventricle. They make their exits from the cranium by means of the middle compartments of the jugular foramina, and are distributed to the mucous membrane of the pharynx and back of the tongue (Plate 13, Fig. 2, No. 16).

The *tenth cranial nerves* (or *pneumogastric*) also appear on the restiform bodies, in close proximity to the preceding nerves (Plate 6, Fig. 2, No. 21). Their fibres of origin arise from special nuclei in the inferior part of the fourth ventricle, and soon blend together, forming single nerve-trunks which pass through the jugular foramina and are distributed to the pharynx, larynx, heart, lungs, œsophagus, and stomach (Plate 36, No. 61, and Plate 37, No. 32). The pneumogastric nerve is of extreme interest and importance, and is often called the *vagus nerve,* from its wandering course.

The *eleventh cranial nerves* (or *spinal accessory*) are each composed of two separate parts, an upper or accessory part, which arises from the medulla below the pneumogastric, and a lower part, which arises from the spinal cord (Plate 6, Fig. 2, No. 23). The deep origin of the upper part commences in a special nucleus about the *calamus scriptorius* in the fourth ventricle. The spinal part of this nerve is composed of fibres which originate as low down on the cord as the fifth cervical vertebra, and it enters the skull at the foramen magnum to join the accessory part. The combined nerve then passes out of the jugular foramen with the pneumogastric and glosso-pharyngeal nerves, the acces-

sory portion blending with the pneumogastric, while the spinal portion (Plate 13, Fig. 1, No. 8, and Plate 21, No. 13) supplies the sterno-mastoid and trapezius muscles.

The *twelfth cranial nerves* (or *hypoglossal*) appear on the surface of the medulla oblongata, in the grooves between the olivary bodies and the anterior pyramids (Plate 6, Fig. 2, No. 46). The special nuclei from which the fibres of these nerves originate are to be found on the floor of the fourth ventricle in front of and nearer the middle line than the nuclei for the pneumogastric nerves. The fibres are formed into two bundles which pierce the dura mater through separate openings and afterward combine within the anterior condyloid foramina, their final distribution being to the muscles of the tongue (Plate 13, Fig. 2, No. 19) and the depressor muscles of the hyoid bone and larynx.

It will be noticed that most of the cranial nerves originate in the neighborhood of the fourth ventricle (or ventricle of the cerebellum) and the top of the medulla oblongata. These portions of the brain are therefore of the greatest importance. The pons Varolii and the medulla oblongata, which rest upon the basilar portions of the occipital and sphenoid bones, have in the natural state interposed between them and the bone, as well as between them and the superposed cerebrum and cerebellum, a quantity of cerebro-spinal fluid which collects in the *anterior* and *posterior sub-arachnoidean spaces.* This fluid serves to equalize pressure and affords resistance to shock, especially from the effects of injury by *contre-coup.* The sub-arachnoid space communicates with the ventricular cavities of the brain by the foramen of Magendie, which is an aperture in the pia mater closing in the fourth ventricle. The aqueduct of Sylvius connects the fourth ventricle with the third ventricle at the base of the brain, and the latter is connected in front with the lateral ventricles by the foramen of Monro.

The *medulla oblongata* (Plate 6, Fig. 9, No. 24) is the upper expanded extremity of the spinal cord on a level with the lower border of the foramen magnum. It is a white, pyramidal body, two and one-half centimetres, or about an inch, in length, and is partially divided anteriorly and posteriorly by median fissures. The *anterior median fissure* ends

in the *foramen cæcum* just below the pons Varolii. The *posterior median fissure* expands into the floor of the fourth ventricle. Each half of the medulla oblongata consists of four longitudinal masses,—viz., the *anterior pyramids*, the *lateral tracts* and *olivary bodies*, the *restiform bodies*, and the *posterior pyramids*. The *anterior pyramids* increase in breadth as they approach the pons Varolii, through which their fibres pass to reach the crura cerebri. They are continuous with the anterior columns of the spinal cord, and consist of *motor* fibres. When the anterior pyramids are separated at their commencement, their inner nerve-fibres, below the surface, are readily seen decussating at the bottom of the anterior fissure. The outer fibres do not decussate, and ascend directly upward. An injury received upon one side of the brain is followed by loss of motion on the opposite side of the body (*cross-paralysis*), which effect is explained by the decussation of the inner fibres of the medulla which are continuous with the fibres of the lateral tracts of the opposite sides.

The *lateral tracts* are situated on the outer side of the anterior pyramids. The *olivary bodies* project from the upper part of the lateral tracts, being separated by a depression from the pons. They are embraced by the ascending fibres of the lateral tracts as they diverge on their way to the pons and restiform bodies. These ascending fibres from the lateral tracts are more or less obscured by the *arciform fibres*, which loop across the surface and connect the anterior pyramids with the restiform bodies. The roots of the hypoglossal, glosso-pharyngeal, pneumogastric, and spinal accessory nerves emerge from the medulla in the immediate vicinity of the olivary bodies. The *olivary nucleus* is a layer of gray tissue within the olivary body upon each side, which presents on section a jagged toothed appearance, in consequence of which it is also called the *corpus dentatum*. The *restiform bodies* are the continuation upward of the posterior columns of the spinal cord. They diverge toward the cerebellum, constituting its inferior peduncles, and with the posterior pyramids assist in forming the lateral boundaries of the fourth ventricle. Gray matter is found in the interior of the restiform bodies.

The *posterior pyramids* (*funiculi graciles*) are the two slender bundles on each side of the posterior median fissure, which diverge at the apex

of the fourth ventricle. The enlargement upon each of the posterior pyramids at this locality is called the *clava*, and it contains within it some gray matter, the *nucleus gracilis.* From the clava the posterior pyramid on each side gradually dwindles, its fibres passing to the cerebrum along the floor of the fourth ventricle and constituting with the fibres from the adjacent restiform body, which take the same course, the *fasciculi teretes.* The *transverse striæ* on the floor of the fourth ventricle, which form the roots of the auditory nerves, are derived from the arciform fibres above described. They are chiefly composed of the fibres which do not enter the olivary body, but wind round beneath it and over the restiform body. The decussation of the fibres of the lateral tracts and the divergence of the restiform bodies and posterior pyramids cause a change in the arrangement of the gray matter in the upper part of the medulla oblongata, from the characteristic disposition of the gray matter in the spinal cord. The anterior cornua of the cord become separated from the mass of gray matter, owing to the decussation of the fibres from the lateral tracts, and behind the olivary bodies form the *lateral nuclei.* The rest of the gray matter of the anterior cornua in this locality is broken up into an interlacement of fibres, the *formatio reticularis,* by the longitudinal fibres from the lateral tracts being intersected by the deeper set of arciform fibres.

The pons Varolii (Plate 6, Fig. 2, No. 39) is situated just above the medulla oblongata, and in the skull rests upon the body of the sphenoid bone. It serves to connect the fibres of the medulla below with the cerebellum behind it by means of the crura cerebelli, as well as with the cerebrum above by means of the crura cerebri. The pons is defined above and below by very prominent margins, the upper margin arching over the crura cerebri, and the lower one, much less curved, distinguishing it from the medulla. A shallow groove in the middle of its anterior surface accommodates the basilar artery (Plate 11, Fig. 1, No. 15). A section of the pons will show that the anterior portion is mainly composed of white transverse fibres crossed by white longitudinal fibres. The longitudinal fibres ascend from the medulla to pass to the cerebrum, and occasion the prominences on each side of the anterior surface of the

pons. The transverse fibres connect the hemispheres of the cerebellum. These fibres are arranged in layers having gray matter variously disposed among them, especially in the locality of the fourth ventricle, where most of the cranial nerves have their origin.

The cerebellum in the skull (Plate 5, Fig. 2, Nos. 14 and 27) occupies the inferior occipital fossæ, being protected by the tentorium of the dura mater from the weight of the overlying posterior lobes of the cerebrum. It consists of two lateral lobes or hemispheres separated posteriorly by the falx cerebelli of the dura mater and joined anteriorly by the *vermiform process*, or *central lobe*.

The cortical surface, which is darker than that of the cerebrum, is arranged in parallel curved folds, with intervening fissures which vary in depth from the centre and subdivide the surface into lobules. There are four lobules on each hemisphere, the *marginal lobule*, the *lobulus gracilis*, the *cuneiform* or *digastric lobule*, and the *amygdala* or *tonsil lobule*. The *horizontal fissure* separates the upper and lower surfaces of each hemisphere of the cerebellum. The space between the two hemispheres below is called the *valley*. The upper surface consists of the expanded middle lobe, which is here designated the *superior vermis*. In front there is a *notch* into which the optic lobes are received, the surface overlapping the superior peduncles of the cerebellum and the valve of Vieussens. Behind them is another notch, into which the internal occipital protuberance projects. The *superior vermis* is subdivided into four parts. The *central lobule* stands out prominently in front; beneath this and over the valve of Vieussens is the *lingula*, a flattened transverse lamella, with small ridges extending into it from the crura cerebelli, the *frænula*. Behind the central lobule is the *monticulus cerebelli*, and posteriorly is the smaller portion called the *commissura simplex*.

The lamellæ constituting the monticulus continue into the *quadrilateral lobules* on each side, and those which form the commissura pass to the *posterior* or *crescentic lobules*. The *inferior vermis* can best be seen after removing the *amygdalæ*. It consists of three portions,—the *pyramid*, the *uvula*, and the *nodulus*. At the anterior part of the under surface is the *sub-peduncular lobule*, or *flocculus*. Passing from the nodulus to the floc-

Fig.

Fig. 2

culus is a thin valve-like fold of white matter, which is called the *posterior medullary velum.* This velum as it passes from the cerebellum becomes a very delicate layer of tissue covered with pia mater, and closes in the fourth ventricle. A longitudinal section of one of the hemispheres (Plate 11, Fig. 3, and Plate 12) will disclose a mass of white substance with radiating branches upon which the gray cortical substance is infolded. This is the *arbor vitæ* of the cerebellum (Plate 8, Fig. 1, No. 12). The white substance of each hemisphere contains in its centre a nucleus of gray matter, the *corpus dentatum.*

The function of the cerebellum has been concluded from physiological observations to be the co-ordination of muscular movements. As above described, the cerebellum is connected with the medulla oblongata by the fibres which ascend from the restiform tracts and constitute the *inferior peduncles,* or *inferior crura.* The lateral parts of the pons Varolii are the *middle peduncles,* or *middle crura,* of the cerebellum; and its *superior peduncles,* or *superior crura,* are the fibres which connect it with the cerebrum. The innermost fibres of the superior peduncles decussate beneath the corpora quadrigemina, so that some fibres from one half of the cerebrum are continued into the opposite half of the cerebellum. Many of these fibres have been traced into the corpora dentata. Each of the superior peduncles (*processus e cerebello ad testes*) forms the upper part of the lateral boundary of the fourth ventricle, and is connected with its opposite fellow by means of the *valve of Vieussens,* or *superior medullary velum.* The valve is a thin layer of gray matter which forms the upper wall or roof of the important fourth ventricle (Plate 8, Fig. 2, No. 25).

The *fourth ventricle* is the space between the cerebellum and the posterior surfaces of the medulla oblongata and the pons Varolii. Upon vertical section (Plate 8, Fig. 1, No. 10) it appears triangular in shape. This subdivision of the general ventricular cavity is the first part of the primordial central canal formed in the fœtus. As just stated, the fourth ventricle is roofed over by the valve of Vieussens, bounded on each side by the superior peduncles of the cerebellum, and behind by the diverging posterior pyramids and restiform bodies.

Inferiorly the arachnoid membrane is continued on to the posterior

surface of the spinal cord, an aperture usually existing here, called the *foramen of Magendie,* by which the ventricle communicates with the subarachnoidean space. A median furrow exists in the floor of this ventricle, which begins below in a pit (the ventricle of Arantius) and ends in the aqueduct of Sylvius. The divergence of the inferior cerebellar peduncles from this median furrow constitutes a resemblance to the point of a quill pen, and forms the *calamus scriptorius* of the old anatomists. The *obex* is an arching fold of tissue hanging over the apex of the calamus scriptorius. On each side of the median furrow are longitudinal eminences, the *fasciculi teretes,* which are crossed by the *transverse striæ* (or *striæ acousticæ*) toward the posterior part of the ventricle. Externally to the fasciculus teres on each side is a shallow groove which terminates below in a depression, the *fovea posterior,* within which is the *cinereous eminence.* The *fovea anterior* is another depression in this groove, opposite the widest part of the ventricle. The *auditory eminences* are on each side between the foveæ. These are crossed by the above-mentioned *striæ acousticæ.* The *locus cæruleus* is the name given to a variable bluish-gray nucleus in the upper angle of the ventricle. Besides these objects on the floor of the fourth ventricle there are the nuclei of the cranial nerves which originate here. The pia mater (*velum interpositum*), lining the fourth ventricle, is continued into the third ventricle by the aqueduct of Sylvius (or *iter a tertio ad quartum ventriculum*). The aqueduct is about half an inch long, and contains in its walls a large amount of gray matter, in which are the nuclei for the third, fourth, and upper part of the fifth cranial nerves. In front of and above the aqueduct of Sylvius are two pairs of bodies,—the *corpora quadrigemina* (Plate 8, Fig. 2, No. 24), or more properly the *optic lobes,* as they give origin to the optic nerves. They are relatively smaller in man, although their size in most animals bears relation to the power of sight. In birds there is only one pair of optic lobes; in the early stage of the human embryo there is only one pair also, but about the seventh month of fœtal life this pair is subdivided into two by a transverse groove. The posterior pair are the smallest, and are called the *testes;* the anterior pair, the *nates,* are larger and of a darker color. Immediately in front of the nates is situ-

ated a very vascular cone-shaped body,—the *conarium*, or *pineal gland.* It is about the size of a cherry-stone, and consists of many small follicles containing cells. These cells have a gritty substance within them (*acervulus cerebri*) consisting of carbonate of calcium and phosphate of calcium and of magnesium. This curious little body is larger in the child and in the adult female than in the adult male. Its function is unknown, but in birds is supposed to be associated with their homing instinct. The pineal gland is connected with the cerebrum by two white bands or crura (the *peduncles of the pineal gland*) which extend forward upon the inner sides of the optic thalami in the lateral walls of the third ventricle.

The *third ventricle* is the narrow oblong fissure into which the aqueduct of Sylvius, which passes beneath the corpora quadrigemina, opens anteriorly. Its floor is formed by the parts within the inter-peduncular space at the base of the brain,—viz., the posterior perforated space, the corpora albicantia, the tuber cinereum, the infundibulum, and the lamina cinerea (Plates 6 and 8). The velum interpositum is stretched across above, and with the *fornix*, the arching layer of white matter beneath the corpus callosum, forms the roof of the third ventricle.

The cavity of this ventricle is crossed by *three* commissural bands. The *posterior commissure* is just in front of the pineal gland, and is composed of white fibres which serve to connect the optic thalami. The *middle* or *soft commissure* is about half an inch broad, composed of gray matter, and also serves to connect the optic thalami. It is not always found even upon careful examination. The *anterior commissure* is a round white cord in the fore part of the cavity of the ventricle, the fibres of which pass through the adjacent corpora striata and extend into the temporo-sphenoidal lobes of the cerebrum. Just behind the anterior commissure is the *foramen of Monro*, an aperture leading into a short passage which soon branches after the manner of the letter Y, thus affording a communication between the third ventricle and the two lateral ventricles, by which the choroid plexuses of opposite sides are joined. The *velum interpositum* is a duplicature of the pia mater which is projected into the ventricular cavity of the cerebrum through the breach between its posterior lobes and the cerebellum (the transverse fissure of Bichat, Plate 8, Fig.

2, No. 22). Its shape corresponds to that of the fornix, its projecting borders being the convoluted fringes called the *choroid plexuses* (Plate 11, Fig. 2, Nos. 8 and 19). These plexuses consist of minute arteries and veins in connective tissue. In the centre of the velum are two large veins (the *venæ Galeni*) which convey the blood from the great cerebral ganglia into the straight sinus (Plate 4, Fig. 1, No. 9).

The ganglionic masses at the base of the brain consist of two pairs. The anterior are called, from their internal arrangement of alternate white and gray layers, the *corpora striata.* The posterior are the *optic thalami,* which are oval, elevated masses placed on each side of the third ventricle, and, embracing the crura cerebri, project portions of their upper surfaces in the floors of the lateral ventricles. They are exposed by removing the choroid plexuses. They are composed of gray substance covered with a superficial thin layer of white tissue. The upper surface of each thalamus is subdivided by an oblique groove into an *anterior tubercle* and a *posterior tubercle,* or *pulvinar.* Beneath and behind the optic thalami on each side are two small gray eminences, known as the *corpora geniculata, internum* and *externum* according to their position. They are in relation to the roots of the optic tract (the *brachia*), and are connected posteriorly by white bands with the corresponding corpora quadrigemina.

The inner margins of the optic thalami are covered by the choroid plexuses, which separate them from the *fornix,* which is the layer of white matter arching over the inter-thalamic region and enclosing the third ventricle.

The *fornix* consists of a triangular central portion, the *body,* the broadest part of which is posterior to and closely connected with the corpus callosum, and anterior and posterior prolongations, known as the *pillars* or *crura of the fornix.* The *posterior pillars* descend from the outer angles of the body into the middle cornua of the lateral ventricles, constituting the *hippocampi majores* and terminating in the *pes hippocampi.* In their course they are in contact with the pulvinar of the optic thalamus on each side. The *anterior pillars* curve downward from the front of the body of the fornix, leaving the corpus callosum about the position of the foramen of Monro in the floor of the third ventricle, and, receiving

the peduncles of the pineal gland and fibres from the tænia and septum lucidum, pass to the base of the brain, their component fibres twisting in a figure-of-eight manner and returning upward and backward into the fore portions of the optic thalami. The curve which the fibres of each anterior pillar take at the base of the brain forms the *corpus albicans* of that side, as has been previously stated in the view of that region.

On the portion of the under surface of the fornix which rests on the velum interpositum there are some transverse fibres which pass from the corpus callosum and form the *lyra*.

The *septum lucidum* (Plate 8, Fig. 2, No. 6) is a delicate, almost translucent, vertical partition extending from the front of the fornix, where it bends downward, and attached above and below to the under surface of the corpus callosum. It consists of two layers, gray on the inside and white without, and the space between them is called the *fifth ventricle*. This septum serves to divide the upper ventricular space within the hemispheres of the cerebrum into the *right* and *left lateral ventricles*. In cases of serous effusion within the general ventricular cavity of the brain the septum is often ruptured and free communication exists from side to side.

The *lateral ventricles* (Plate 11) are semilunar in shape, and consist of a central part, or *body*, and *anterior*, *middle*, and *posterior cornua*, which extend respectively into the frontal, temporo-sphenoidal, and occipital lobes. The floor of the central portion of either of the lateral ventricles presents many objects of interest, which have the following relative positions. Posteriorly the margin of the posterior pillar of the fornix (the *corpus fimbriatum*) appears as a white cord accompanying the hippocampus major and sometimes called on this account the *tænia hippocampi*. In front of this is the choroid plexus, which usually extends so far forward into the cavity that very little of the subjacent optic thalamus is seen unless it is purposely uncovered. Beyond the thalamus, and separating it from the caudate portion of the corpus striatum, or anterior ganglionic mass, is the white band called from its course the *tænia semicircularis*. The tænia descends anteriorly in connection with the anterior pillar of the fornix, and blends with the fibres composing the corpus albicans, as previously

described. Posteriorly it passes into the middle cornu of the lateral ventricle, apparently losing itself in the white substance in that cavity, but eventually terminating in the gray mass, the *nucleus amygdalæ.* Owing to the upper surface of the tænia being somewhat harder than its deeper part, it was called by Tarinus the *horny band.*

In the fore part of the centre of the lateral ventricle is seen the *intra-ventricular portion* of the *corpus striatum* (Plate 11, Fig. 2, No. 15). This ganglionic centre is best understood by making a horizontal section through it from the tænia semicircularis outward, where it appears to consist of five parts. The intra-ventricular portion, or the *caudate nucleus,* of the corpus striatum, above mentioned, is a gray, pear-shaped mass, the broad part of which is directed forward into the lateral ventricle, and its narrow end, the *tail* or *surcingle,* is continued into the middle cornu as far as the nucleus amygdalæ. The surface of the caudate nucleus in the recent state is covered with a plexus of veins which empty into the venæ Galeni. The *extra-ventricular portion* or *lenticular nucleus* (Plate 11, Fig. 1, No. 6) of the corpus striatum is the largest, and is lodged within the white substance of the hemisphere, being separated from the caudate nucleus by a layer of white matter, the *internal capsule* (Plate 11, Fig. 1, No. 12).

On the external surface of the lenticular nucleus is another layer of white tissue, the *external capsule* (Plate 11, Fig. 1, No. 30), which again separates this portion from a thin layer of gray matter, the *claustrum.* External to the latter is the white matter which is subjacent to the central lobe, or island of Reil, the claustrum being formed by a portion of the under surface of the convolutions of the latter turned inward.

A vertical transverse section of the lenticular nucleus demonstrates that it is composed of three smaller nuclei, the inner one gray, the middle dark yellow, and the outer of a reddish color. These parts are separated by layers of fibres which originate in the convolutions of the operculum. The *nucleus amygdalæ* underlies the corpus striatum, and is in relation with the tail of the caudate nucleus, being continuous with the deep-seated cortex of the temporal lobe. The caudate and lenticular nuclei are united by many gray striæ, which cross the internal capsule and give to the mass the peculiar striation to which it owes its name.

The *internal capsule* consists of white fibres passing between the caudate nucleus and the thalamus opticus and the lenticular nucleus. Its anterior portion, or *caudo-lenticular limb,* is composed of fibres from the frontal lobe, and its posterior portion, or *thalamo-lenticular limb*, consists of motor fibres from the operculum on their way through the crusta of the crus cerebri to the anterior pyramid of the medulla oblongata. Fibres from the temporal and occipital lobes also compose the extreme end of the *thalamo-lenticular limb*, passing through the crus cerebri and pons to the cerebellum. There are also fibres passing from the cortex to the thalamus and to the gray matter in the pons. These fibres diverge above the caudate nucleus and intermingle with the fibres of the corpus callosum. The *external capsule* is thinner than the *internal*, with which it is continuous behind. It consists of white fibres in connection with the claustrum derived from the crus cerebri and the anterior commissure of the third ventricle.

The *posterior cornua* (or digital cavities) of the lateral ventricles are not always equally developed in both hemispheres, and they are sometimes absent. They usually curve backward into the substance of the occipital lobes. In the floor of each posterior cornu is a claw-shaped eminence, the *hippocampus minor*, which is also known as the *calcar*, because it is produced by the infolding of the contiguous convolutions of the calcarine fissure. Between the posterior and middle cornua there is a smooth mass of variable size, the *eminentia collateralis* (or the *pes accessorius*), formed by the inward protrusion of the collateral fissure. The *middle* or *descending cornua* are the largest of the prolongations of the cavity of the lateral ventricles. They pass downward into the temporo-sphenoidal lobes toward the base of the brain, making remarkable curves backward, outward, and downward round the backs of the optic thalami, and forward and inward round the crura cerebri, resembling somewhat the horns of a ram, and hence are also known as the *cornua Ammonis.* They terminate in close proximity to the fissures of Sylvius. Continuous with the hippocampus minor, from the posterior cornu on each side, is a long, white, rounded eminence which follows the curve of the middle cornu and occupies the principal part of its cavity, the

PLATE 8.

Figure 1.

The convolutions and fissures of the inner surface of the left hemisphere of the cerebrum, and median section through the base of the brain, cerebellum, pons Varolii, and medulla oblongata. (From same brain as in Plates 6 and 7.)

1. The ascending frontal convolution.
2. The fissure of Rolando.
3. The ascending parietal convolution.
4. The præcuneus, or quadrate lobe.
5. The parieto-occipital fissure.
6. The cuneus, or cuneate lobe.
7. The calcarine fissure.
8. The corpora quadrigemina.
9. The aqueduct of Sylvius, leading from the third to the fourth ventricle.
10. The fourth ventricle.
11. The transverse fissure.
12. The arbor vitæ of the cerebellum.
13. The left lobe of the cerebellum.
14. The superior frontal convolution.
15. The calloso-marginal fissure.
16. The fornicate convolution.
17. The corpus callosum.
18. The anterior bend of the calloso-marginal fissure.
19. The septum lucidum.
20. The fornix.
21. The thalamus opticus.
22. The inferior frontal convolution.
23. The corpus albicans.
24. The optic nerve.
25. The fissure of Sylvius.
26. The motor oculi nerve.
27. The pons Varolii.
28. The temporo-sphenoidal lobe.
29. The medulla oblongata.

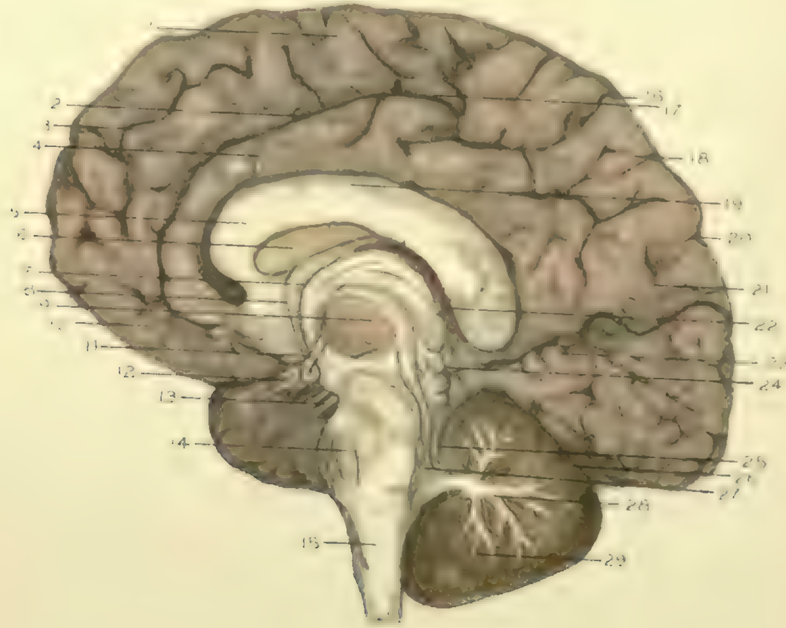
Figure 2.

The convolutions and fissures of the inner surface of the right hemisphere of the cerebrum, and median section through the base of the brain, cerebellum, pons Varolii, and medulla oblongata. (From same brain as in Plates 6 and 7.)

1. The superior frontal convolution.
2. The calloso-marginal fissure.
3. The middle frontal convolution.
4. The fornicate convolution.
5. The corpus callosum.
6. The septum lucidum.
7. The fornix.
8. The anterior pillar of the fornix.
9. The optic thalamus.
10. The inferior frontal convolution.
11. The corpus albicans.
12. The optic nerve.
13. The motor oculi nerve.
14. The pons Varolii.
15. The medulla oblongata.
16. The fissure of Rolando.
17. The calloso-marginal fissure.
18. The quadrate lobe.
19. The corpus callosum.
20. The parieto-occipital fissure.
21. The cuneate lobe.
22. The velum interpositum.
23. The calcarine fissure.
24. The corpora quadrigemina.
25. The valve of Vieussens.
26. The great transverse fissure.
27. The fourth ventricle.
28. The arbor vitæ of the cerebellum.
29. The right lobe of the cerebellum.

Fig. 1

Fig. 2



hippocampus major. This body is formed by the reduplication of the hippocampal convolution. Extending along its upper margin is the *tænia hippocampi,* or white band continuous with the posterior pillar of the fornix, as previously described. At the lower extremity of the hippocampus major there are four or five small elevations with intervening depressions, producing a fancied likeness to the paw of an animal, and hence called the *pes hippocampi.* Along the inner border of the hippocampus major about the hippocampal fissure (which is really the lateral part of the transverse fissure) there is an edge composed of white fibres from the fornix (*corpus fimbriatum*) passing to the uncinate gyrus. Here there is a notched ridge of gray matter, the *fascia dentata,* which derives its name from the arrangement of the choroid arteries as they pass through the *dentate fissure* into the middle cornu. The *anterior cornua* of the lateral ventricles curve outward from each other into the substance of the frontal lobes round the caudate nucleus of the corpus striatum.

The general roof of the lateral ventricles is formed by the *corpus callosum,* which, owing to its being formed of white transverse fibres extending between the hemispheres, is called the *great transverse commissure* of the cerebrum. The *corpus callosum* (Plate 8, Fig. 2, No. 5) is thicker and broader at its back part, the *splenium,* which is in relation with the transverse fissure where the pia mater enters the ventricles. It arches forward over the ventricular cavity, ten centimetres, or about four inches, in length, and anteriorly bends downward and backward, forming the *genu.* The lowest part of the bend is called the *rostrum* (or beak), and terminates in the two *peduncles of the corpus callosum,* they severally disappearing in the fissures of Sylvius. Upon the upper surface of the corpus callosum there is a middle groove, or *raphé,* and, in the recent state, on each side of this groove are readily distinguished two white *longitudinal striæ,* called the *nerves of Lancisi.* Parallel and external to these are other fibres, the *lateral striæ.* The anterior cerebral arteries proceed from before backward on the upper surface, and are here called the arteries of the corpus callosum (Plate 4, Fig. 1, No. 16). On its external borders the corpus callosum is overlapped on each side by the *gyri fornicati* (Plate 8). The borders themselves are known as the *labia*

cerebri, and the spaces between them and the commissure are the *ventricles of the corpus callosum.* If a section through the brain is made, either vertically or horizontally, the white matter is spotted with dots (the *puncta vasculosa*), due to the escape of blood from the severed vessels of the medullary substance (Plate 11, Fig. 2, No. 13).

The medullary substance of the cerebrum consists of fine white fibres, which may be described as longitudinal, transverse, and diverging fibres. The *longitudinal fibres* compose the fornix, the striæ longitudinales, the tæniæ semicirculares, the gyri fornicati, the gyri uncinati, and the peduncles of the pineal gland. The *transverse fibres* connect the two hemispheres, and are found in the corpus callosum and the anterior and posterior commissures. The *diverging* (or *peduncular*) *fibres* are derived partly from the crusta and partly from the tegmenta of the crura cerebri, having originated in the cord and medulla oblongata. Those from the crusta are derived mainly from the anterior pyramids of the medulla, receiving *en route* through the crusta fibres from the gray walls of the aqueduct of Sylvius and the locus niger, and pass forward and outward to the internal capsule between the caudate and lenticular nuclei on each side. They distribute fibres to the nuclei of the corpora striata and receive others from them, and after issuing from the capsule radiate in all directions toward the cortical surface of the cerebrum, forming the *corona radiata.* Many of the fibres of the crusta have been traced directly through the internal capsule to the cortex. The so-called *pyramidal tract* is composed of such fibres passing to the gray surface-matter of the ascending frontal and parietal convolutions in the neighborhood of the fissure of Rolando. Some bundles of the fibres on the outer portion of the crusta have been traced into the occipital convolutions of the hemispheres, and are known as the *direct sensory tracts.* The fibres from the tegmenta are derived from the reticular formation of the medulla oblongata, and are joined by fibres from the superior and middle peduncles of the cerebellum, and by fibres from the corpora quadrigemina, terminating apparently in the sub-thalamic region and the optic thalami. Many fibres from the external portions of the optic thalami have been traced radiating into the temporo-sphenoidal and occipital lobes. They constitute

the *radiatio thalami.* Besides these there are arcuate or *association fibres,* which bring adjacent convolutions into communication.

Much patient and critical study has been given to the unravelling of the fibres of the medullary structure of the cerebro-spinal system by anatomists. Briefly stated, the conclusions drawn from their observations establish that there are three sets of nerve-centres, and three sets of nerve-fibres through which impressions are transmitted to and from the periphery and to and from the gray cortical surface of the hemispheres. The nerve-centres are the gray matter of the cord and medulla oblongata, the optic thalami and corpora striata, and the cortical surface of the convolutions. The nerve-fibres are those which connect the periphery with the gray matter of the cord and medulla, those which connect the gray matter of the cord and medulla with the basal ganglionic centres, the optic thalami, and the corpora striata, and those which bring these centres into relation with the cortical surface of the convolutions. The precise function of the basal ganglionic centres is unknown, but from their relations as above described it may be inferred that the *corpora striata* are connected with *motion,* and that the *optic thalami* are connected with *sensation.* In both there is *crossed action;* and the above inference is further emphasized by clinical and pathological data, as well as by physiological experiments.

Apoplexy attended by hemorrhage of one of the lenticulo-striate arteries into the substance of either of the corpora striata is followed by paralysis of motion of the opposite side of the body, without loss of sensation; and similar involvement of either of the optic thalami is followed by loss of sensation in the opposite side, without diminution of power of motion.

The approximate topographical relation of the anterior limit of the corpora striata to the external surface of the head may be indicated by drawing a line on each side from the stephanion to the pterion (Plate 2, Fig. 1). The same relative bearing which the optic thalami, within the head, probably hold may be mapped out by an anterior vertical line drawn from the bregma to the external auditory opening on each side, and a posterior vertical line drawn from the parietal eminence to the

asterion (Plate 2, Fig. 1). A line drawn from the ophryon backward on the side of the head to the occiput, through the asterion, will indicate the position of the lateral ventricle, its anterior limitation corresponding to a line from the stephanion to the pterion, and its posterior limitation to a line from the parietal eminence to the asterion, as above described.

The operation of trephining for tapping the ventricles for intra-cranial hemorrhage is very hazardous, and requires careful consideration of the position of the corpus striatum and optic thalamus and their relations to the highly vascular region of the Sylvian fossa and island of Reil, where the cortical vessels are large and near their origin from the middle cerebral and internal carotid arteries. If the procedure is attempted, in order to avoid this important area the best position for the application of the trephine will be on a line drawn from the ophryon to the lambda, and midway between the external auditory opening and the asterion. This will expose the temporo-sphenoidal lobe about the junction of the middle and inferior temporo-sphenoidal convolutions. A fine trocar passed in a direction forward and obliquely downward will (in the adult) reach the corresponding lateral ventricle. If the ventricle be distended with blood its walls will be reached two and half centimetres, or about an inch, from the surface. In two instances within the author's experience where exploratory tapping was practised, although no benefit was derived from the operation, no ill effects were noticed, and the autopsies revealed no injury to the medullary substance even upon microscopic examination.

THE REGION OF THE EAR.

The ear (auris), or **organ of hearing,** consists of *two accessory portions,* the *pinna,* or *auricle,* for the purpose of collecting and converging the aërial vibrations to the *external meatus,* which conducts them to the *middle ear,* or *tympanum,* and the *essential portion,* the *internal ear,* or *labyrinth,* where the sensation of sound is produced by their ultimate impression upon the auditory nerve.

The pinna, or **auricle** (Plate 17), projects from the side of the head, being movably attached to the external auditory opening of the

temporal bone by the anterior and posterior auricular ligaments, and the anterior auricular, superior auricular, and posterior auricular muscles. The *anterior ligament* connects the front of the pinna to the root of the zygoma, and the *posterior ligament* the back of the pinna to the mastoid process. The *anterior* and *superior auricular muscles* (Plate 20, No. 42) arise from the temporal arch of the aponeurosis of the occipito-frontalis muscle, and are respectively attached to the front and upper part of the pinna. The *posterior auricular muscle* consists of a few fleshy bundles which arise from the base of the mastoid process and are inserted into the back of the pinna. These auricular muscles are very imperfectly developed in man, and consequently the auricle possesses a limited functional capability, and persons who have been deprived of it suffer very little loss in their power of hearing. The *pinna* is formed of a yellow fibro-cartilage, with some fat and connective tissue, covered with integument, which is expanded from the side of the head and very closely adherent to the cartilage. The auricular cartilage is an incomplete irregular plate presenting many peculiar elevations and concavities. The deficiencies (or fissures of Santorini) in the cartilage are bridged over by fibrous tissue. The folded border of the pinna is called the *helix* (Plate 17, No. 9); the elevation within it, the *antihelix;* and the groove between them is the *fossa of the helix* (or *fossa scaphoidea*). The upper part of the antihelix divides anteriorly and encloses the *fossa of the antihelix* (or *fossa ovalis*). The *concha* is the deep concavity leading into the meatus. In front of the concha is the *tragus* (Plate 17, No. 13), a conical elevation which is usually covered with some conspicuous hairs. Behind the tragus, at the outer part of the concha, is the *antitragus.* The tragus and antitragus are separated by a deep notch, the *incisura.* Below the concha is the soft pendulous portion of the pinna, the *lobule* (Plate 17, No. 16), which consists of fat and fibrous tissue covered with skin and without any cartilaginous basis. There is great variability in the development of the auricle, both as to its conformation and as to the manner in which it is set on the side of the head. The margin of the helix is often irregular and presents a conical process at its upper part. The *skin* covering the pinna is thin, with very little

PLATE 9.

Figure 1.

The right side of the head, with the scalp removed to show the topographical survey of the skull in its relations to the brain. The temporal muscle and its fascia have also been removed to show their ridges.

1. The junction of the coronal and sagittal sutures (*the bregma*).
2. The cut edge of the scalp tissues.
3. The parietal eminence.
4. The junction of the lambdoid and sagittal sutures (*the lambda*).
5. The position of the junction of the occipital, parietal, and temporal bones (*the asterion*).
6. The external occipital protuberance (*the inion*).
7. The coronal suture.
8. The point where the ridge for the temporal fascia crosses the coronal suture (*the superior stephanion*).
9. The frontal eminence.
10. The point of intersection of the ridge for the temporal muscle and the coronal suture (*the inferior stephanion*).
11. The superciliary ridge, covered with the tissues of the eyebrow (*the ophryon*).
12. The top of the squamo-parietal suture.
13. The junction of the nasal bones with the frontal (*the nasion*).
14. The position of the anterior inferior angle of the parietal bone, and its junction with the great wing of the sphenoid and frontal and temporal bones (*the pterion*).

Figure 2.

The right side of the head with the skull removed, showing the dura mater and the main branches of the great meningeal artery. This also illustrates the contiguous relations of the tissues of the scalp to the tables of the skull in their surgical application, and especially to the operation of trephining.

1. The scalp.
2. The pericranium.
3. The epicranial aponeurosis.
4. The outer compact table of the skull.
5. The diploic structure.
6. The inner compact table of the skull.
7. The posterior branch of the great meningeal artery.
8. The dura mater.
9. The anterior branch of the great meningeal artery and its vein.
10. The middle branch of the great meningeal artery and its vein.
11. The position of the anterior inferior angle of the parietal bone, corresponding to the root of the great meningeal artery.

Fig. 1

Fig. 2

subcutaneous tissue, and is closely adherent to the subjacent perichondrium, especially within the fossæ or concavities. On the helix and the back of the pinna it is somewhat looser, and may become extremely swollen and painful from the tenseness produced by inflammation of the parts, as in erysipelas. There are numerous sebaceous glands within the scaphoid fossa and the concha. Besides the bands of fibrous tissue which fill up the breaches in the auricular cartilage, and which are known as the *intrinsic ligaments*, there are various small muscles which extend between the different parts of the cartilage. On the convex surface toward the side of the head there are some muscular fibres extending from the concha to the posterior border of the helix, called the *transverse auricular muscle*, and others from the top of the concha to the top of the back of the antihelix, called the *oblique auricular muscle.* On the outer or concave surface of the concha are the *tragicus*, consisting of vertical fibres on the front of the tragus, the *antitragicus*, which is usually well developed and extends obliquely from the antitragus to the caudate process of the helix, the *helicis major*, which ascends along the front part of the helix from the caudate process to the highest part, where it begins to curve backward, and the *helicis minor*, which passes from the floor of the concha anteriorly to the end of the helix. All these intrinsic auricular muscles are supplied by branches of the facial nerve.

The *arteries* supplying the pinna are derived from the posterior auricular, temporal, and occipital arteries. The *veins* pass into the temporal vein. The *nerves* are branches from the great auricular branch of the superficial cervical plexus, the auriculo-temporal branch of the inferior maxillary, the posterior auricular branch of the facial, and the auricular branch (Arnold's) of the pneumogastric nerve. The latter especially supplies the concha.

The external auditory meatus is the oval passage which extends three centimetres, or about an inch and a quarter, obliquely inward and forward from the concha to the tympanum, conforming to the petrous portion of the temporal bone. It is a curved oval canal, with the greatest diameter in the vertical direction at the concha, and in the transverse direction at the membrana tympani, which completely closes

the bottom of the meatus. Owing to the oblique direction of the membrana tympani, the floor of the canal is a little longer than the roof, which is highest at the middle. The middle of the meatus is also the narrowest portion, and affords the greatest obstacle to the removal of foreign bodies from the bottom of the canal. The first twelve millimetres, or half-inch, of the meatus consists of a tubular continuation of the cartilage of the pinna, which is firmly connected with the osseous portion, although it is incomplete at the upper and back part, where the breach is filled in with fibrous tissue. The *cartilaginous portion of the canal* may be somewhat straightened by drawing the pinna upward, outward, and backward. It is lined with integument which contains many sebaceous and ceruminous glands. The sebaceous glands are often the seat of minute abscesses which are extremely painful. The ceruminous glands secrete the cerumen or ear-wax. The *osseous portion* is two centimetres, or about three-quarters of an inch, in length, and more constricted than the cartilaginous portion, being formed by the auditory plate above and by the tympanic plate below. The auditory plate extends to the tympanum, while the tympanic plate at its inner end is grooved for the insertion of the membrana tympani. The *upper wall* of the osseous portion of the meatus is separated from the cranial cavity, as already stated, by only a thin layer of bone, which is apt to give way in abscess or bone-disease and occasion meningitis. The *anterior wall* is in relation to the condyle of the lower jaw and part of the parotid gland. The *posterior wall* separates the meatus from the mastoid cells, but is so thin a partition that it is liable to break down in mastoid disease. The *inferior wall* is very dense, and corresponds to the vaginal process of the temporal bone. The skin within the osseous portion of the meatus is very thin and adherent to the periosteum, and contains no sebaceous glands.

The *ceruminous glands* resemble in structure hypertrophied sweat-glands, and are mainly confined to the skin lining the cartilaginous portion, although a few are placed along the roof of the osseous part of the canal. The skin at the bottom of the meatus is spread over the membrana tympani, where it forms a cul-de-sâc, so that after maceration the pouch of cuticle may be removed, showing the exact form of the meatus.

The membrana tympani (Plate 3, Fig. 5, No. 17) is a thin, semi-transparent, oval membrane inserted obliquely downward and inward in a bony groove at the termination of the meatus. In children this membrane holds a more oblique position than in the adult, owing to the imperfect development of the bony walls of the auditory canal. There is generally, although not always, a deficiency in the upper part of the groove in which the membrane is attached, called the *notch of Rivinus*, which is merely covered by the skin lining of the meatus, and which may allow the escape of fluid from within the middle ear without perforation of the membrane. The membrana tympani is less securely attached at this notch than at the rest of its circumference: therefore when it is subjected to any violent concussion it is liable to give way at this point. The structure of the membrane is fibrous tissue, with most of the fibres radiating from the centre, which receives the handle of the malleus and is slightly drawn inward, so that this portion of the membrane is called the *umbilicus*. The membrana tympani is covered on the outer side by the skin lining of the meatus, as just stated, and upon its inner surface by the mucous lining of the tympanum. It is supplied by the tympanic branch of the internal maxillary artery, which enters by the Glaserian fissure, and it receives a branch from the auriculo-temporal nerve.

The tympanum, or middle ear, is an irregular cavity, within the petrous portion of the temporal bone, which serves as an air-chamber between the auditory meatus and the labyrinth or internal ear, having a communication anteriorly with the pharynx by the Eustachian tube, so that the atmospheric pressure is equal on both sides of the membrane. The *tympanic cavity* (Plate 3, Fig. 5, No. 5) is somewhat broader behind and above than it is below and in front, and it is traversed by three little bones, the *ossicles*, which are movably connected with one another by ligaments and extend between the membrana tympani and the fenestra ovalis of the labyrinth, so that they serve to conduct the vibrations across the tympanum. It is not quite twelve millimetres, or half an inch, long from before backward, about six millimetres, or a quarter of an inch, in its vertical direction, and from two to four millimetres, or from one-twelfth to one-sixth of an inch, in width from its outer to its inner boundaries. The

bony walls of this cavity are very thin, and have important relations to the neighboring structures. The *upper wall*, or *roof*, is a thin bony plate on the anterior surface of the petrous portion and close to the junction of the squamous portion of the temporal bone. There is a squamo-petrosal suture in the roof of the tympanum in infancy which may admit of inflammation of the lining membrane being transmitted to the dura mater within the cranial cavity. The *floor* is a very narrow, delicate plate of bone, overlying the jugular fossa, and perforated anteriorly by a small foramen for the tympanic branch of the glosso-pharyngeal (Jacobson's) nerve, which arises from the ganglion of Andersch and eventually passes out of the tympanic cavity through the upper tympanic canal into the middle fossa of the cranium, and is known as the lesser superficial petrosal nerve, whence it passes by the innominate canal in the sphenoid bone to join the otic ganglion. The *outer wall* is mainly formed by the membrana tympani and the margin of the bony groove which accommodates it. The latter has in it three small openings,—viz., the *Glaserian fissure*, a little slit at the upper and front part of the bony ring, which lodges the processus gracilis of the malleus and the so-called laxator tympani muscle, and gives passage to the tympanic branch of the internal maxillary artery; the *iter posterius*, behind the membrana tympani, which gives entrance to the chorda tympani nerve; and the *iter anterius*, which runs parallel with the Glaserian fissure and leads into the canal of Huguier, giving exit to the chorda tympani nerve. The *inner wall* is vertical and very uneven, and presents various objects of interest. At the upper part is the curved ridge corresponding to the *aqueduct of Fallopius* (Plate 3, Fig. 5, No. 9), which accommodates the facial nerve. Just below this is the *fenestra ovalis*, which communicates with the *vestibul*e of the internal ear, but in the recent state is filled with a membrane to which is attached the base of the stapes. Below this is the *promontory*, which corresponds to the first turn of the cochlea, and is slightly grooved for the branches of the tympanic plexus of nerves. Below and posterior to the promontory is the *fenestra rotunda*, which is an opening at the bottom of a conical depression leading to the scala tympani of the cochlea, but in the recent state is closed by a membrane (the *membrana tympani*

secundaria). The conical eminence in front of the ridge of the aqueduct of Fallopius and behind the fenestra ovalis is called the *pyramid.* It is hollow, and contains the stapedius muscle, the little round tendon of which passes through a foramen in the apex to be inserted into the stapes. The *posterior wall* is perforated by openings of various sizes leading into the cellular spaces within the mastoid process, which are lined with the same mucous membrane as the cavity of the tympanum, and are mostly filled with air. Owing to the contiguity of structure, the mastoid cells are often involved in suppurative disease of the middle ear; their proximity to the lateral sinus has already been referred to (page 6).

The *anterior wall* of the tympanum is very thin, and in direct relation with the carotid canal, from which it receives the tympanic branch of the internal carotid artery. At its upper part is an opening in a conical eminence which transmits the tendon of the tensor tympani muscle. This eminence is sometimes called the *anterior pyramid.* A bony septum separates it from the channel which conveys the air from the pharynx into the tympanum, the *Eustachian tube.* This channel begins near the *processus cochleariformis* in the lower part of the anterior wall, and runs for twelve millimetres, or about half an inch, to the angle of junction of the petrous and squamous portions of the temporal bone, where it has a rough, jagged extremity to which is attached a cartilaginous continuation two and a half centimetres, or about an inch, in length. The mucous lining of the tympanum is continued through the Eustachian tube to its pharyngeal opening, which is behind the inferior meatus of the nose (Plate 12, No. 32) and in close relation with the tonsil gland.

The ossicles which extend across the tympanum are the *malleus* (or hammer), the *incus* (or anvil), and the *stapes* (or stirrup), which are articulated to one another by ligamentous bands and so arranged that they serve to render the membrana tympani tense or loose according to the degree of impulse of the vibrations. The *malleus* consists of a *head,* which is attached by a suspensory ligament to the roof of the tympanum and articulates with the incus posteriorly; a *neck,* the constriction below the head, tapering into the *manubrium* (Plate 3, Fig. 5, No. 14), to be fastened to the fibrous portion of the tympanic membrane along its

upper part, as far as the umbilicus, as already described; the *processus gracilis*, a very long delicate projection from a tubercle below the neck, extending into the Glaserian fissure and receiving the insertion of the ligamentous band formerly called the *laxator tympani muscle;* and the *processus brevis*, a slight elevation at the root of the manubrium, resting upon the membrana tympani and receiving the insertion of the tensor tympani muscle. The *incus* is shaped somewhat like a bicuspid tooth with widely separated unequal fangs. The *body* of the incus has a glenoid depression for the reception of the head of the malleus. The *long process* (Plate 3, Fig. 5, No. 16) is placed nearly parallel with the manubrium of the malleus, and articulates with the head of the stapes. The *short process* extends backward to be fixed in the neighborhood of the mastoid openings. The *stapes* is a beautifully constructed little bone very closely resembling a miniature stirrup. The *neck* is a constriction just below the point where the head is connected with the long process of the incus, and it receives the insertion of the tendon of the stapedius muscle after it comes through the posterior pyramid. The *base* is the oval plate of bone, at the opposite ends of the delicate bony crura, which rests upon a membrane covering the fenestra ovalis, and thus completes the bony chain and serves to convey the impulse of the vibrations upon the membrana tympani to the fluid within the vestibule of the internal ear. Besides the ligamentous bands which support the ossicles and retain them in position, there are capsular bands at the articulations between the malleus and the incus, and between the incus and the stapes. The amount of motion between these little bones is very slight, and is produced by the various actions of the tensor tympani and stapedius muscles. The *tensor tympani muscle* arises from the apex of the petrous portion of the temporal bone and from the cartilaginous portion of the Eustachian tube, being lodged within a special canal above the latter, and is inserted into the handle of the malleus. It is supplied by a nerve from the otic ganglion, in relation to the internal maxillary artery, and by drawing the head of the malleus inward renders the membrana tympani tense.

The *stapedius muscle* arises from the hollow of the posterior pyramid, and its tendon, which is supplied with a synovial sheath, is inserted into

the neck of the stapes. It receives a little branch from the facial nerve, which comes through an opening in the adjacent aqueduct of Fallopius, and the action of the muscle probably serves to increase the tension upon the fluid within the vestibule. The *mucous lining* of the tympanic cavity is closely attached to the periosteum, except where it is pierced by the vessels and nerves, and is reflected over the membranes which fill in the bottom of the meatus and the fenestra ovalis, and completely surrounds the ossicles. It has been already stated that the mucous lining is continuous from the pharynx by the Eustachian tube and is prolonged into the mastoid cells. The mucous lining is supplied with filaments from the tympanic plexus of nerves.

The *facial nerve* (or *seventh cranial nerve*) enters the internal auditory meatus in the apex of the temporal bone, and, after interchanging a few fibres with the auditory nerve within the meatus, enters the *aqueduct of Fallopius,* which is a tortuous canal in the upper and posterior margin of the inner wall of the tympanum above the fenestra ovalis, and at the back of the tympanic cavity passes vertically downward to the stylo-mastoid foramen. The facial nerve within the aqueduct presents a gangliform swelling (*intumescentia gangliformis*) in the neighborhood of the *hiatus Fallopii,* which is an oblique slit in the anterior border of the petrous part of the temporal bone, giving passage to the *large petrosal nerve,* which, combining with the sympathetic branch from the carotid plexus, forms the *Vidian nerve,* and thus brings the facial nerve in relation with the *spheno-palatine* (Meckel's) *ganglion* (Plate 3, Fig. 2, No. 6). From the gangliform swelling also arise the *small petrosal nerve* and the *external superficial petrosal nerve,*—the former passing to the otic ganglion and the latter to the sympathetic plexus around the middle meningeal artery. The tympanic branch of the facial nerve, as already stated, passes through a foramen in the descending part of the aqueduct to enter the base of the posterior pyramid to supply the stapedius muscle. In this vicinity the facial nerve receives a communicating filament from Arnold's nerve. Between this point and the stylo-mastoid foramen, where the facial nerve makes its exit from the skull, an important branch, the *chorda tympani nerve* (Plate 3, Fig. 2, No. 24), passes upward in a bony channel parallel to

PLATE 10.

Figure 1.

The dura mater removed to show the vessels of the pia mater over the cortical surface of the right hemisphere.

1. The cut tissues of the scalp.
2. The pia mater enveloping the outer surface of the right hemisphere, and showing the complexity of the course of the external cerebral veins and arteries, which mask the underlying convolutions.
3. Section of the skull-cap.

Figure 2.

The pia mater removed from the right hemisphere to show the surface-markings of the fissures and convolutions, and a topographical survey of the subdivisions of the motor area of the opercular region, according to the most recent investigations of the localization of the centres of function of the cortical surface of the cerebrum.

1. The centre for the movements of the face (the expressions).
2. The centre for the movements of the fingers.
3. The centre for the movements of the thumb.
4. The centre for the movements of the wrist.
5. The centre for the movements of the shoulder and elbow.
6. The centre for the movements of the hip, knee, and leg.
7. The centre for the movements of the foot and toes.
8. The cut tissues of the scalp.
9. The fissure of Rolando (in this case joining the horizontal branch of the fissure of Sylvius).
10. The calloso-marginal fissure.
11. The superior parietal convolution.
12. The inter-parietal fissure.
13. The inferior parietal convolution.
14. The ascending parietal convolution.
15. The angular convolution.
16. The parieto-occipital fissure.
17. Section of the skull-cap.
18. The superior occipital convolution.
19. The superior temporal fissure.
20. The middle occipital convolution.
21. The centre for the movements of the lips, tongue, throat, and larynx.
22. The speech centre.
23. The superior frontal convolution.
24. The posterior frontal fissure.
25. The ascending frontal convolution.
26. The middle frontal convolution.
27. The inferior frontal convolution.
28. The ascending branch of the fissure of Sylvius.
29. The horizontal branch of the fissure of Sylvius.
30. The fork of the fissure of Sylvius.
31. The superior temporal convolution.

N. B.—The figures on Plates 9 and 10 were taken in succession from the head of an adult male, in remarkable physical health, and represent the structures in their normal condition and position. Comparison of the series will demonstrate the perplexities attending the study of cerebral localization, and the parts to be encountered in cerebral surgery.

PLATE 10.

Figure 1.

The dura mater [illegible] to show [illegible] vessels of the pia mater [illegible] the cortical surface of [illegible] right hemisphere.

1. The [illegible] of the scalp.
2. The pia mater enveloping the outer surface of the right [illegible]re, and showing the complexity of the course of the external cerebral veins and arteries, [illegible] the underlying convolutions.
3. Section of the skull-cap.

Figure 2.

The pia mater removed from the right hemisphere to [illegible] the [illegible] convolutions, and a topographical survey of the subdivisions of the motor area of the opercular region, according to the most recent [illegible] of the localization [illegible].

1. The centre for the movements of the [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. The centre for the [illegible] and elbow.
6. The centre for the [illegible]
7. The [illegible] the foot and toes.
8. [illegible]
9. The centre of [illegible] this case [illegible] the horizontal branch of the fissure of Sylvius).
10. The calloso-marginal fissure.
11. The superior parietal convolution.
12. The [illegible] parietal [illegible]
13. The inferior parietal convolution.
14. The ascending parietal convolution.
15. [illegible]
16. [illegible]
17. [illegible] of the skull-cap.
18. The [illegible] convolution.
19. [illegible]
20. [illegible]
21. The [illegible] of the [illegible], tongue [illegible]
22. The [illegible]
23. The superior frontal convolution.
24. The posterior frontal fissure.
25. The ascending frontal convolution.
26. The [illegible] convolution.
27. The [illegible] frontal [illegible]
28. The ascending branch of the fissure of Sylvius.
29. The horizontal branch of the fissure of Sylvius.
30. The fork of the fissure of Sy[illegible]
31. The superior temporal convolution.

N. B. [illegible] and 10 were taken in succession from the head of an adult [illegible] physical [illegible] strate the [illegible] surgery

Fig 1

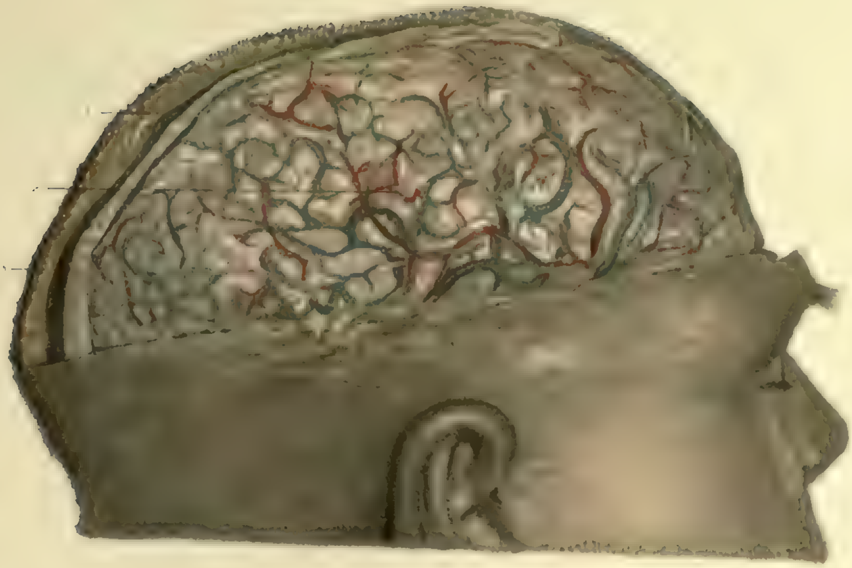
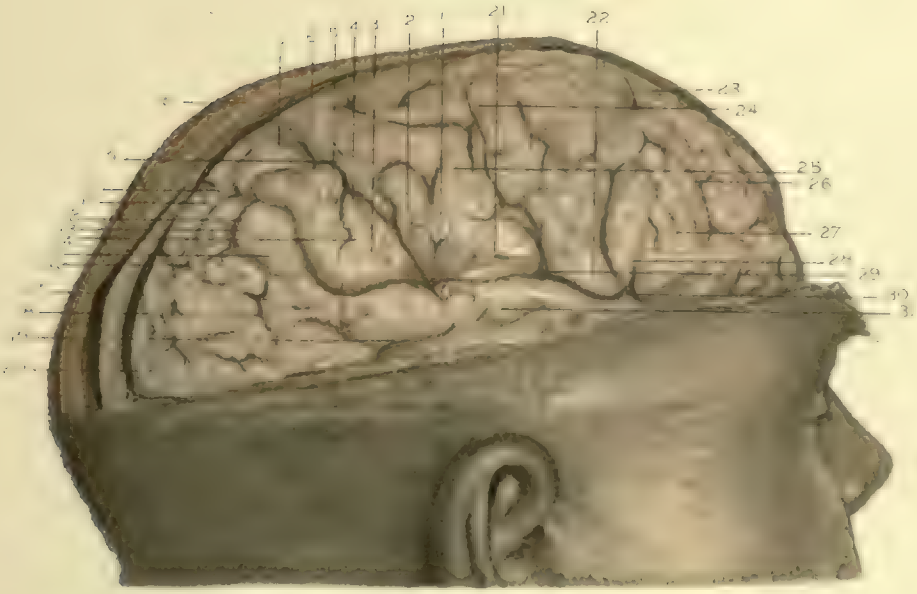


Fig 2



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the aqueduct and enters the cavity of the tympanum through a foramen (the *iter posterius*) below the posterior pyramid and close to the membrana tympani. It is surrounded with the mucous lining of the tympanum, and, passing between the manubrium of the malleus and the long process of the incus, it emerges through a foramen (the *iter anterius*), the opening of a special bony canal (the *canal of Huguier*), close to the Glaserian fissure. Thence it descends between the two pterygoid muscles, behind the middle meningeal artery and in close relation to the auriculo-temporal and inferior dental nerves, and blends with the lingual branch of the inferior maxillary nerve, being eventually distributed to the submaxillary ganglion and the lingualis muscle. The chorda tympani nerve is generally believed to originate from the nerve of Wrisberg, intermediate between the auditory and facial nerves. Owing to its comparative distribution in the lower animals, it is supposed to preside over the sense of taste at the anterior portion of the tongue. Recently this nerve has been traced through the geniculate ganglion of the facial nerve to the fourth ventricle, and it is therefore considered as an independent cranial nerve, with the special function concerned in the power of speech (Sapolini).

The facial nerve communicates in the temporal region by filaments with the pneumogastric, the glosso-pharyngeal, the great auricular, and the auriculo-temporal nerves, and with the carotid plexus; and on the face with the numerous sensory branches from the trifacial nerve. A lesion of the facial nerve within the aqueduct of Fallopius from fracture of the base of the skull is attended by paralysis of the facial muscles, which is often a diagnostic feature of such an injury in connection with other symptoms.

The tympanum is very richly supplied with blood by little arteries from various sources. The tympanic branches of the internal maxillary and internal carotid arteries, the petrosal branch from the middle meningeal artery, and minute branches from the ascending pharyngeal artery, enter from the front, while from behind the stylo-mastoid branch from the posterior auricular artery penetrates by the aqueduct of Fallopius. The veins empty into the superior petrosal and lateral sinuses, and into the middle meningeal and pharyngeal veins.

The internal ear, or labyrinth, consists of a very complex arrangement of spaces and channels in the most compact part of the temporal bone. There are three special compartments, known as the vestibule, the semicircular canals, and the cochlea. The *vestibule* is an irregular oblong cavity situated between the tympanum and the internal auditory meatus, having the fenestra ovalis on its outer wall, by which it communicates with the tympanum when the parts are macerated, but in the recent state it is closed by the base of the stapes and its annular ligament, and on its inner wall there is a shallow depression in front, called the *fovea hemisphærica*, the lower part of which, the *macula cribrosa*, is perforated by numerous foramina for the transmission of the filaments of the auditory nerve. Behind the fovea hemisphærica there is the *crista*, a ridge, with usually a little opening, called the *aqueduct of the vestibule*, which gives passage to a small vein. In the roof of the vestibule there is a depression, the *fovea hemi-elliptica*, which lodges the utricle. The five openings of the semicircular canals are in the posterior part of the vestibule, and anteriorly there is the opening into the cochlea: so that the vestibule is the common cavity in which all the others communicate. The *semicircular canals* are three bony canals above and somewhat behind the vestibule. Each canal forms about two-thirds of a circle; and they differ in their directions, so that they are called superior, posterior, and external. Each canal is dilated at one end,—the *ampulla*,—corresponding to a similar dilatation of the membranous lining of the labyrinth. The canals all open into the posterior part of the vestibule by both of their extremities, but, as one of the openings is made up of the extremities of two of the canals, there are only *five* distinct openings.

The *superior semicircular canal* is vertical in direction, and arches across the anterior part of the petrous portion of the temporal bone, forming a rounded elevation on its surface. Its outer ampullated extremity opens into the upper part of the vestibule. Its non-ampullated extremity opens into the back of the vestibule by a common orifice with the similar extremity of the *posterior semicircular canal*. The latter is also vertical, but is placed at a right angle with the superior canal, being parallel to the posterior surface of the petrous bone. It is the longest of the three canals.

The *external semicircular canal* is placed horizontally, and is the shortest. The *cochlea* closely resembles a common snail's shell, and is placed almost horizontally at the anterior part of the labyrinth. Its base corresponds to the bottom of the internal auditory meatus, and is perforated by the cochlear branches of the auditory nerve. Its apex is in relation with the upper and front part of the inner wall of the tympanum. The cochlea consists of a conical-shaped central axis, the *modiolus,* and a gradually tapering *spiral canal* which winds round the modiolus to the extent of two and a half turns, terminating at the apex of the cochlea in a little dome,—the *cupola.*

The *modiolus* (or *columella*) is quite thick at its base, but gradually diminishes toward the apex, where it terminates in the *infundibulum.* Its interior is composed of cancellous bone, through the meshes of which vessels and nerves pass to the spiral lamina. The *arteria centralis modioli* is a little artery which is accommodated in a canal within the centre of the modiolus. The *spiral canal* is subdivided by a delicate plate, the *lamina spiralis,* partly bony (the *lamina ossea*) and partly membranous (the *membrana basilaris*), into two parallel tubes, called the *scalæ.* The *scala tympani* is the larger and lower of these tubes, and is in relation with the tympanum by the membrane attached to the fenestra rotunda; the *scala vestibuli* is the upper tube, and is in direct connection with the vestibule. Owing to a deficiency in the top of the modiolus, the two scalæ communicate with each other in the cupola by the opening called the *helicotrema,* which is partly bounded by a hook-shaped process at the end of the lamina (ossea) spiralis. The scala vestibuli is furthermore subdivided by the oblique membrane of Reissner, which separates a portion of its upper part from the rest and thus forms the *scala media,* or *cochlear canal.* At the junction of the bony lamina with the modiolus there is a very small winding canal, the *canalis spiralis modioli,* which is occupied by an enlargement of the cochlear nerve, whence the nerves pass to the organ of Corti. The *aquæductus cochleæ* is a small aperture leading to a canal which opens on the basilar surface of the petrous bone and transmits a vein from the cochlea to the internal jugular vein. The membranous continuation of the osseous lamina spiralis is thickened into an

elevation, the *limbus*, or *denticulate lamina*, which overhangs the furrowed margin (the *sulcus spiralis*) of the bony lamina. The upper border of the sulcus is called the *labium vestibulare*, the lower, the *labium tympanicum*. From the latter a delicate membrane (the *membrana basilaris*) extends to the outer bony wall of the cochlea, completing the scala tympani. Where the basilar membrane is attached to the outer wall there is a projection of connective-tissue cells,—the so-called *ligamentum spirale*. The basilar membrane increases proportionately as the osseous lamina decreases toward the cupola. The *membrane of Reissner* is the oblique membrane which partitions off the cochlear canal from the scala vestibuli. It is a very delicate layer of connective tissue, covered on the cochlear surface with epithelium, and is continuous with the periosteum lining the upper surface of the lamina spiralis. The *cochlear canal* is formed on its inner wall by the membrane of Reissner, on its outer wall by the periosteum, on its lower wall by the limbus spiralis and the basilar membrane. Within the periosteum on the outer wall there is a conical eminence of connective tissue which accommodates a tiny vein,—the *vas spirale*. Between this and the attachment of Reissner's membrane there is another eminence, which consists of numerous anastomosing vessels,—the *striæ vascularis*.

The basilar membrane sustains the complex and wonderful arrangement of the *organ of Corti*, upon which the ultimate filaments of the auditory nerves are distributed. The organ of Corti is covered over by the *membrana tectoria*, which is a fine layer of connective tissue extending between the labium vestibulare of the osseous lamina and the attachment of Reissner's membrane and placed parallel to the basilar membrane. The entire osseous labyrinth is lined with a very thin *periosteum*, which consists of fibro-elastic tissue with cell-elements and serves as a matrix for blood-vessels. From this tissue is secreted a small quantity of fluid known as the *perilymph*, or *liquor Cotunnii*, which surrounds and suspends the *membranous labyrinth*, a tubular reproduction of the osseous labyrinth, which also encloses a little fluid, the *endolymph*, or *liquor Scarpæ*. The membranous labyrinth receives the distribution of the terminal filaments of the auditory nerves, which, owing to their inter-

position between the two fluids, are thus rendered susceptible to the most delicate vibrations. The *vestibular portion* of the membranous labyrinth forms two unequal communicating sacs, the *utricle* and the *saccule.* The *utricle* is lodged, as previously stated, in the fovea hemi-elliptica, and communicates with the openings of the semicircular canals. It is the larger of the two pouches, and is thickest (the macula) at the crista, where the nerve-branches enter. The *saccule* rests in the fovea hemisphærica in front of the utricle. It is connected with the cochlear portion of the membranous labyrinth by the *canalis reuniens,* and in a roundabout way with the utricle by the aqueduct of the vestibule, thus establishing an uninterrupted channel for the endolymph throughout the membranous labyrinth.

On the inner walls of the utricle and saccule there are many minute concretions of carbonate of calcium which seem to be in connection with the ends of some of the nerves. They are called *otoliths* (or ear-stones).

The *membranous semicircular canals* correspond to the bony canals which contain them. They are connected at their ampullated extremities by the vessels and nerves to the contiguous periosteum, but in the rest of their extent they are only about one-third of the diameter of the osseous canals. The connection at the ampullated extremities with the periosteum forms a partial septum, the *crista acoustica.* The membranous structure consists of three layers, an outer *fibrous layer,* a middle, the *tunica propria,* and an inner or *epithelial layer.* In the ampullated portions the epithelial layer presents spindle-shaped cells with ciliated processes, the *auditory hairs.*

From the description already given of the relations of the membrane of Reissner, the basilar membrane, and the membrana tectoria within the scala vestibuli of the cochlea, it will be seen that they serve practically to constitute a shrunken membranous cast of the bony cochlea, resembling in a measure the membranous pouches within the vestibule and the semicircular canals. This *membranous cochlea,* or *cochlear duct,* is the scala media above mentioned: it commences opposite the promontory of the tympanum, and, after winding along the middle of the cochlear canal, ends at the cupola in a closed extremity. It is connected with the mem-

PLATE 11.

Figure 1.

Transverse (coronal) section through the head just in front of the ears, passing through the basilar part of the occipital bone below and the bregma above. Showing the section of the brain, *in situ*, at the middle of the lateral ventricles. The figure represents the parts as seen from the front.

1. Section of the superior longitudinal sinus of the dura mater, showing its triangular shape.
2. The cut tissues of the scalp.
3. The diploic structure, between the outer and inner tables of the skull.
4. The dura mater over the right cerebral hemisphere.
5. The gray involuted cortical substance of the brain.
6. The white medullary substance of the brain, showing puncta vasculosa.
7. Section of the inferior longitudinal sinus of the dura mater, showing its oval shape.
8. The corpus callosum.
9. The fornix.
10. The right lateral ventricle.
11. The right fissure of Sylvius.
12. The internal capsule.
13. The external capsule.
14. The right optic thalamus.
15. The basilar artery on the pons Varolii.
16. The right ear.
17. The osseous portion of the right Eustachian tube.
18. The right internal carotid artery.
19. The right parotid gland.
20. The right internal jugular vein.
21. The right pneumogastric nerve.
22. The right longus colli muscle.
23. The first frontal convolution.
24. The falx cerebri, in the longitudinal fissure.
25. The second frontal convolution.
26. The third frontal convolution.
27. The left lateral ventricle.
28. The internal capsule.
29. The left fissure of Sylvius.
30. The external capsule.
31. The left optic thalamus.
32, 33, and 34. First, second, and third temporal convolutions.
35. The pons Varolii.
36. The basilar portion of the occipital bone.
37. The osseous portion of the left Eustachian tube.
38. The left ear.
39. The left parotid gland.
40. The left pneumogastric nerve.
41. The left internal carotid artery.
42. The left internal jugular vein.
43. The left longus colli muscle.
44. The pre-vertebral fascia.

Figure 2.

Horizontal section of the head, with the brain in position, showing the lateral ventricles and adjacent parts.

1. The position of the foramen cæcum.
2. The anterior median fissure (or fore part of the longitudinal fissure).
3. The anterior cornu of the left lateral ventricle.
4. The intra-ventricular portion of the left corpus striatum (or the *nucleus caudatus*).
5. The position of the foramen of Monro.
6. The extra-ventricular portion of the left corpus striatum (or the *nucleus lenticularis*).
7. The left optic thalamus.
8. The left portion of the choroid plexus.
9. The splenium of the corpus callosum.
10. The posterior cornu of the left lateral ventricle.
11. The posterior median fissure (or hind part of the longitudinal fissure).
12. The frontal sinus of the skull.
13. The frontal lobe of the brain, with puncta vasculosa.
14. The anterior cornu of the right lateral ventricle.
15. The intra-ventricular portion of the right corpus striatum (or the *nucleus caudatus*).
16. The extra-ventricular portion of the right corpus striatum (or the *nucleus lenticularis*).
17. The right optic thalamus.
18. The fornix.
19. The right portion of the choroid plexus.
20. The middle cornu of the right lateral ventricle.
21. The posterior cornu of the right lateral ventricle.
22. The point where the longitudinal sinus terminates at the torcular Herophili.

Figure 3.

Antero-posterior section of the head, with brain in position, through the middle of the *right* hemisphere. The orbital muscles are seen in relation to the eyeball.

1. Section through the fissure of Rolando.
2. The occipito-parietal fissure.
3. The corpus callosum.
4. The corpus striatum.
5. The optic thalamus.
6. The velum interpositum.
7. Position of the fourth ventricle.
8. The transverse fissure, with the tentorium cerebelli.
9. The arbor vitæ of the cerebellum.
10. The inion.
11. The frontal lobe of the right hemisphere.
12. The frontal sinus.
13. The superior rectus muscle.
14. The right eyeball.
15. The external rectus muscle.
16. The capsule of Tenon.
17. The right optic nerve.
18. The inferior oblique muscle.
19. The inferior rectus muscle.
20. The temporo sphenoidal lobe.
21. The antrum of Highmore, in the right superior maxillary bone.

N. B.—The heads from which all of these figures were taken were very recent and without any hardening preparation, so that the relations of the parts are perfectly preserved. (Figs. 1 and 2 are from male heads, about thirty and thirty-five years of age, and Fig. 3 from a female aged thirty-seven years.)

Fig 1

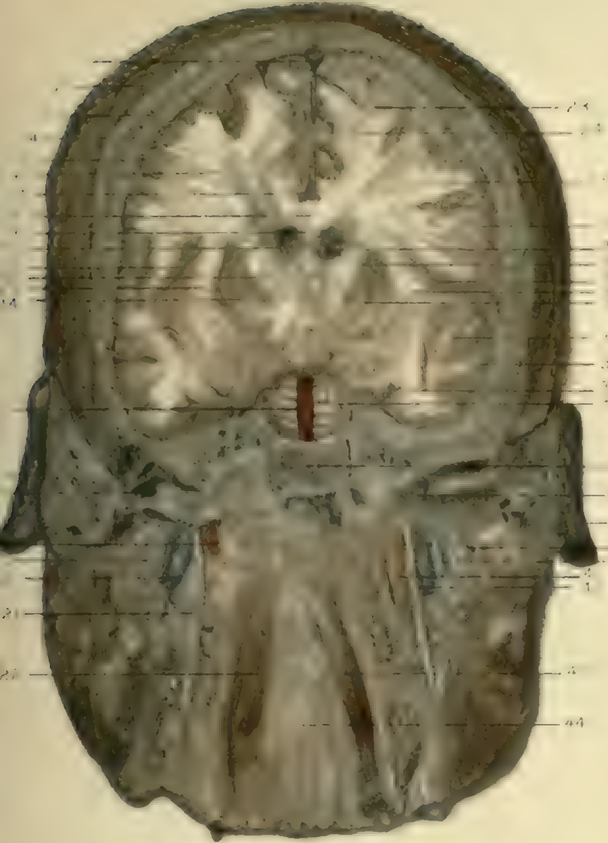
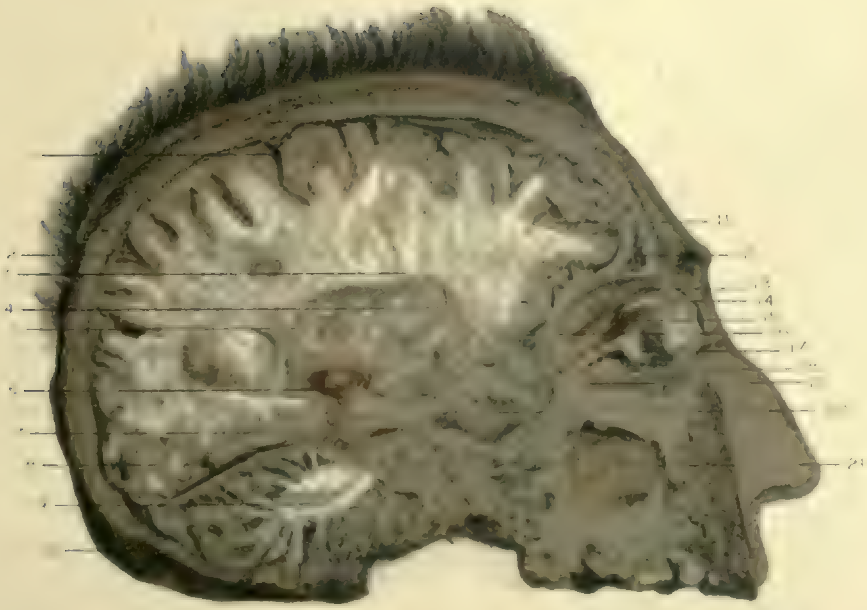


Fig 2

Fig 3



branous semicircular canals by the *ductus reuniens*, and is bathed without by the perilymph and within by the endolymph, like the rest of the membranous labyrinth. It is much more important, however, as it differs greatly in the character and arrangement of the complex structures contained within a portion of its space, which are known as the *organ of Corti*. This organ presents a slight elevation upon the basilar membrane, and appears to be a modification of the lining epithelium following the spiral turns of the membrane throughout its course, whence it was formerly called the *papilla spiralis acoustica*. Microscopic examination demonstrates that it consists of a peculiar arrangement of cells which bear a remarkable similarity to the key-board of a piano-forte. The central cells are rod-like bodies, the *rods of Corti*, which are disposed on the basilar membrane in two sets, an inner and an outer, in such a manner that they incline toward each other, blending at their upper extremities, forming a series of arches, the minute spiral space so enclosed by them being the *tunnel of Corti*. Both the outer and the inner rods are similar in structure and have a broad nucleated base, but they differ materially in shape, the outer being compared to a swan's head, which is received into the sigmoid cavities of several of the inner rods, which are in shape very like the upper extremity of the human ulna. There are a great many more inner rods than outer, and they are shorter and less obliquely placed. There are numerous stiff ciliated processes in relation to the inner and outer rods, called respectively the *inner* and *outer acoustic hair cells*. The acoustic hair cells are believed to be in direct connection with the ultimate fibrils of the cochlear nerves; and the intervals between them and the outer rods are occupied by long fusiform cells, the *supporting cells of Deiters*, which rest upon the basilar membrane. There is a net-like membrane, the *lamina reticularis*, spread out over the summits of the outer hair cells, through which the ciliated processes project. This net-work consists of several rows of plates, or *phalanges*, which dovetail with the phalangeal processes from the summits of the supporting cells. There is a somewhat similar reticular membrane over the ends of the inner hair cells.

The *auditory nerve* (or *eighth cranial nerve*) enters the internal auditory meatus (Plate 3, Fig. 1) with the facial nerve and auditory artery,

and at its bottom passes through a perforated plate, the *lamina cribrosa,* to be distributed to the labyrinth, or internal ear, being divided into the vestibular and cochlear nerves. The facial nerve pursues an independent course along the aqueduct of Fallopius, as already described (page 69).

The *vestibular nerve* becomes at first slightly enlarged, and then divides into various branches, which proceed to the utricle, the saccule, and the ampullæ of the semicircular canals. The *cochlear nerve* immediately within the lamina cribrosa separates into numerous filaments, which enter the canals in the base of the modiolus. Thence they pass outward between the plates of the osseous lamina, through the *ganglion spirale,* to form a minute plexus, the ultimate filaments of which appear to be connected with the inner and outer hair cells of the organ of Corti.

The labyrinth is supplied by the auditory artery, a branch of the basilar artery (Plate 5, Fig. 3) which accompanies the auditory and facial nerves into the internal auditory meatus and divides into vestibular and cochlear branches. These branches correspond to the nerves and ramify over the periosteal lining of the internal ear, receiving branches of communication from the vessels of the tympanic cavity and from the stylomastoid artery, which arises from the posterior auricular branch of the external carotid artery.

In fractures involving the petrous portion of the temporal bone, attended with hemorrhage from the external auditory meatus, the source of bleeding is more generally from the minute arteries of the labyrinth and the tympanum than from the adjacent internal carotid artery or the internal jugular vein, laceration of either of which would be probably immediately fatal. The escape of cerebro-spinal fluid by the same exit is indicative of a fracture implicating the internal auditory meatus (page 7). The pressure of this fluid upon the perilymph within the labyrinth, to which have been attributed some cases of deafness, does not anatomically exist, as the only lymph-extension is by the sheaths of the auditory vessels and is too inconsiderable to admit of any degree of pressure by any amount of intra-cranial effusion.

The *auditory vein* receives its blood from the veins of the labyrinth, and, passing out through the internal auditory meatus, empties it into the

inferior petrosal sinus. There are also emissary veins from the cochlea and vestibule, which, passing through their respective aqueducts, terminate generally in the internal jugular vein.

THE ORBITAL REGION AND THE EYE.

The orbits (Plate 28) are two cavities, one on each side of the upper part of the face, for the lodgement and protection of the eyeballs and their accessory apparatus. Each orbit is formed of the plane surfaces of the contiguous bones of the head and face, peculiarly disposed so that the eye is insured extensive range of vision. These cavities are pyramidal, their bases corresponding to the surface-margins, and their apices extending backward and inward in such a manner that their axes continued backward would meet over the body of the sphenoid bone where the optic commissure rests. The *roofs of the orbits* are formed anteriorly by the vaulted orbital plates of the frontal bone and posteriorly by the lesser wings of the sphenoid bone. The *floors* are formed chiefly by the orbital processes of the superior maxillæ, with the orbital processes of the malar bones anteriorly and the orbital surfaces of the palate bones posteriorly. They are much less concave than the roofs. The *inner walls* are nearly vertical and parallel with each other, while the *outer walls* are divergent. The inner walls are mainly formed by the ossa plana of the ethmoid bone and the orbital surfaces of the lachrymal bones, with portions of the sphenoid behind and the nasal processes of the superior maxillæ in front. The outer walls are formed anteriorly by the orbital processes of the malar bones and posteriorly by the orbital plates of the great wings of the sphenoid bone. At the apices of the orbits the *optic foramina* transmit the optic nerves and ophthalmic arteries. External to the optic foramen at the back part of the outer wall of each orbit is the oblique *sphenoidal fissure,* between the greater and lesser wings of the sphenoid bone, which transmits the ophthalmic division of the trifacial nerve and the nerves to the muscles of the eyeballs (Plate 3, Fig. 2), together with the ophthalmic vein and some sympathetic filaments from the carotid plexus. Continuous with the sphenoidal fissure passing externally in the floor of each

orbit is the *spheno-maxillary fissure,* which in the recent state is bridged over by membrane. From the middle of the spheno-maxillary fissure in the floor of each orbit there extends outwardly a groove which leads into the infra-orbital canal and gives passage to the infra-orbital nerve and infra-orbital artery. Just within the nasal margin of each orbit is the *lachrymal fossa,* formed by the apposition of grooves in the nasal process of the superior maxilla and the lachrymal bone. This fossa is the opening into the *nasal duct,* which conveys the tears into the inferior meatus of the nose. In the sutural line between the ethmoid and frontal bones there are two foramina, the *anterior* and *posterior ethmoidal,* the former transmitting the nasal nerve and anterior ethmoidal vessels and the latter the posterior ethmoidal vessels. The facial opening into each orbit is provided with a somewhat four-sided margin, peculiarly adapted above for the support of the eyebrows and at the circumference for the attachment of the eyelids. The *external angular processes* of the orbits are the outer limits of the superciliary ridges at the junction of the frontal with the malar bones. They are superficial, and important topographical landmarks, as has been previously stated. Two and one-half centimetres, or about an inch, from the external angular processes inward toward the nose, on the borders of the orbital arches there are notches or foramina for the exit, upon the forehead, of the supra-orbital vessels and nerves. The bones forming the floor, the inner wall, and the roof of the orbital cavity are very fragile, the frontal portion of the roof being often only membranous, so that foreign bodies thrust into the orbit may readily penetrate downward into the antrum, inward into the ethmoidal cells, or upward into the cranial cavity. Owing to this latter feature, in abscess of the frontal lobe of the brain it is feasible to make an artificial opening for drainage either through the orbit or through the nasal cavity.

The eyebrows (**supercilia**) consist of the arching folds of the integument connected beneath with the constrictor muscles of the eyelids, the orbicularis palpebrarum and occipito-frontales muscles, and especially the transverse fibres of the orbicularis known as the *corrugator muscles* (Plate 15, No. 22). They surmount the superciliary ridges of the frontal bone, supporting short, thick hairs which at the nasal side of the arch are

directed upward and forward, and for the rest of the arch upward and outward with increasing obliquity.

Below the eyebrows the skin is of very delicate texture, entirely destitute of fat, and spread over the elliptical folds, the *eyelids*, which consist of the so-called tarsal cartilages, attached to the margin of the orbit by the palpebral ligaments, and covered by the extremely thin inner layer of *pale* fibres of the orbicularis muscle, which are connected by loose cellular tissue to the skin. So exceedingly thin and delicate is the covering of the upper eyelid that when it is closed over the eye not only can its blood-vessels be readily seen, but, owing to the translucency of the tissues, often the iris may be distinguished through them. Occasionally there is a cutaneous fold from the upper lid overlapping the inner canthus. The laxity of the cellular tissue of the eyelids is manifest in the œdematous conditions following inflammation or contusion. The skin over the lids is wrinkled transversely, and on the upper lid there is a constant fold which marks the part covering the globe of the eye from that in relation to the soft structures of the orbit. The furrow which exists between the lower lid and the cheek deepens in old age and in many wasting diseases, and produces a peculiar sunken look about the eyes common to those conditions. The upper lid is larger and more movable than the lower. It is mainly by the action of the levator palpebræ muscle upon the upper lid that the eye is exposed, and by that of the orbicular muscle that the eye is closed. The interval between the two lids, the *fissura palpebrarum* or *rictus oculi*, terminates in the inner and outer corners or *canthi*. The size of the rictus varies with the relation of the lids to the eyeball, according as the eyes are directed upward, forward, or downward. When the eye is looking upward (Plate 53, Fig. 1), the rictus is dilated, the upper lid arching as high as the upper margin of the cornea, while a portion of the white sclerotic coat is visible above the lower lid. When the eye is looking straight forward, the upper lid slightly covers the top of the cornea, and the lower lid is on a level with its lower border. When the eyes are downcast, the upper lid covers the cornea as far as the top of the pupil, and the lower is on a line with the lower border of the cornea. The lower lid holds the latter relation also in ordinary closure of

the eyes. The cartilage of the upper lid is larger than that of the lower one, broad in the middle and narrower at each end, while the lower is nearly uniform throughout. These cartilages are attached to the orbital margin by the palpebral ligaments, which are continuations of the periosteum lining the orbit. The attachment of the cartilages to the malar portion of the orbit is by the *external palpebral ligament*, and that to the nasal process of the superior maxilla is by the *internal palpebral ligament*, or *tendo oculi* (Plate 15, No. 25). The latter is a fine, short cord at the inner canthus, which passes from its attachment in front of the lachrymal groove horizontally outward and divides into separate portions for the palpebral cartilages. The angular artery and vein are on the inner side of this tendon (Plate 18, No. 3). The *orbicularis palpebrarum* is the sphincter muscle surrounding the eyelids. It is attached to the tendo oculi and the inner and lower margin of the orbit, while above its fibres blend with those of the occipito-frontalis, and on the cheek with the elevators of the upper lip and nose, and the zygomatici (Plate 15). The fibres of this muscle form oval loops round the eyelids and orbit, the orbital fibres being thicker and redder than those over the eyelids, as already mentioned. Forced contraction of the orbicular muscle serves to push back the eye into the orbit, and affords a soft protective pad in front of it. In winking it is only the palpebral portion of the muscle which contracts. This momentary closure of the lids is accompanied by a slight drawing inward at the inner canthus, which directs the tears toward the *puncta lachrymalia.* The "*crow's-feet*" of old age are the permanent radiating wrinkles produced by the orbital fibres drawing the brows down and the lower lids up.

The *corrugatores supercilii muscles* (Plate 15, No. 22) are deep accessory portions of the orbicular muscles, which arise from the internal angular processes of the orbits, and, passing transversely outward, are inserted into the superficial muscular fibres and skin of the eyebrows. These bunches of fibres have special branches from the facial nerves, by their action wrinkle the forehead vertically, and are the proper muscles of frowning.

The *levatores palpebrarum muscles* arise from the lesser wings of the sphenoid bone in the back parts of the orbital cavities, above the optic

foramina. They pass over the globes of the eyes, terminating in broad thin tendinous insertions at the tarsal cartilages of the upper lids beneath the palpebral ligaments. They are constantly in action when the eyes are open, becoming relaxed in sleep.

The free margins of the eyelids are the thickest parts of the tarsal cartilages. They are straight, and when the eyes are closed are in accurate apposition. Upon their edges the *eyelashes* (*cilia*) are arranged in several rows. The lashes of the upper lids are longer and more numerous than those of the lower lids, and the upper ones curve upward, while the lower curve downward. The bulbs of the lashes are placed between the tarsal cartilages and the overlying muscular fibres. They are supplied with blood from the palpebral branches of the ophthalmic artery, which run parallel with and close to the borders of the lids. If the lids are everted, a number of *sebaceous glands* (*Meibomian*) are to be seen arranged in longitudinal parallel rows on the under surface of the tarsal cartilages. Their orifices are situated behind the lashes, on the margins of the lids, and their function is to prevent the lids from sticking together by their sebaceous secretion. Inflammation of one of these glands results in a small cystic abscess, known as *hordeolum* or stye.

Within the orbit, just behind the external angular process, there is a shallow depression for the lodgement of the *lachrymal gland*, which is about the shape and size of an almond, and whose function is to secrete the tears. It is fastened in its place by a few fibrous bands from the periosteum attached to its upper surface, while below it rests loosely upon the eyeball and its superior and external straight muscles. Sometimes there is an accessory portion to the gland, which from its relation to the upper lid is called the *palpebral portion* (*of Rosenmüller*). The gland is invested by a capsule of connective tissue. In structure the gland resembles very much the salivary glands, being an aggregation of lobes and lobules held together by fibro-cellular tissue. There are about a dozen excretory ducts, which take a parallel course and open in a row of orifices two and one-half centimetres, or about an inch, above the edge of the upper tarsal cartilage, upon the conjunctiva, the mucous lining of the eyelids. The *tears* (*lachrymæ*) are the excessive secretion of the

PLATE 12.

Median antero-posterior vertical section through the head, face, and neck of a powerfully-built man, thirty years of age.

1. The superior longitudinal sinus of the dura mater.
2. Section through the tables of the skull, showing the diploic structure.
3. The cut tissues of the scalp.
4. The falx cerebri.
5. The inferior longitudinal sinus.
6. The venæ Galeni.
7. The straight sinus.
8. The fourth ventricle.
9. Section of the cerebellum, showing the arbor vitæ.
10. The torcular Herophili.
11. The occipital sinus.
12. The medulla oblongata.
13. The spine of the first cervical vertebra.
14. The spine of the second cervical vertebra.
15. Section through the ligamentum nuchæ and muscles and fascia at the nape of the neck.
16. The spine of the third cervical vertebra.
17. The spine of the fourth cervical vertebra.
18. The spine of the fifth cervical vertebra.
19. The spine of the sixth cervical vertebra.
20. The spine of the seventh cervical vertebra (the vertebra prominens).
21. The convolution of the corpus callosum and anterior cerebral vessels.
22. Section of the corpus callosum (showing the genu).
23. The fornix.
24. The crista galli of the ethmoid bone.
25. The frontal sinus.
26. The corpora quadrigemina.
27. The sella turcica, and position of the pituitary body.
28. The sphenoidal sinus.
29. The nasal meatuses.
30. The pons Varolii, resting on the basilar portion of the sphenoidal bone.
31. Breach through the septum of the nose, opening into the middle meatus.
32. The opening into the Eustachian tube.
33. The junction of the soft and hard palates.
34. The vault of the palate.
35. The incisor teeth of the upper jaw.
36. The velum palati (the uvula).
37. The incisor teeth of the lower jaw.
38. The tongue.
39. The pharynx.
40. The epiglottis.
41. The genio-hyoid muscle.
42. The mylo-hyoid muscle.
43. The body of the hyoid bone.
44. The notch in the thyroid cartilage.
45. The ventricle of the larynx.
46. The commencement of the œsophagus.
47. The cricoid cartilage.
48. The spinal cord.
49. The second ring of the trachea.
50. The sterno-hyoid and thyroid muscles.

N. B.—This section was made shortly after death, and photographed immediately, so as to preserve the relations of the structures accurately.

...photographed and colored from Nature by George McClellan, M.D.

lachrymal glands, which, under the influence of the emotions, or from the irritation caused by cold, or by any foreign substance coming in contact with the eye, overflow upon the cheek. Ordinarily the secretion of the gland serves to keep the surface of the cornea constantly moist, and to bathe the conjunctiva so that the movements of the lids and of the eyeball shall be free.

The conjunctiva is reflected from the lids over the front of the eye, and the two portions are known respectively as the *palpebral* and the *ocular*. The palpebral portion is the thicker, is very vascular, and is provided with numerous fine papillæ, inflammation of which occasions the disease called "*granular lids.*" At the inner canthus of the eye the conjunctiva is reduplicated, forming the *plica semilunaris*, and its angle of reflection from the lids to the eyeball is called the *fornix conjunctivæ*. The continuations of the plica are the superior and inferior palpebral folds. When the lids are closed, even in the momentary action of winking, the conjunctiva becomes, as it were, a closed cavity which collects the tears and conveys them to the inner canthus, where there is an oval space between the two lids, the *lacus lachrymalis*. This space is occupied by the *caruncula lachrymalis*, a small, reddish-colored, conical body consisting of a number of follicles and resembling in structure the Meibomian glands. The caruncula secretes the whitish matter frequently noticeable at the inner angle of the eye.

Near the inner canthus there are on the margin of each lid slight elevations, the *papillæ*, with openings, the *puncta*, on their summits. The puncta are the orifices of the *canaliculi*, which pass inward toward the lachrymal sac. The manner in which these orifices are disposed for the reception of the tears is influenced by the action of a slip of muscular fibres from the orbicular muscle. This slip is called the *tensor tarsi* (or *Horner's muscle*), in consequence of its arising from the ridge of the lachrymal bone and being inserted into the tarsal cartilages of both lids near their puncta. This little muscle may also act as a compressor of the lachrymal sac. The canaliculi vary in their course,—a fact which should be thoroughly understood in undertaking to relieve obstruction of either of them by the introduction of probes or the knife. The *superior*

canal first extends upward, and then, bending at an acute angle, passes inward and downward to join the *inferior canal* at its entrance into the tear-sac. The course of the inferior canal (which is the one most often affected) is first downward, and then it abruptly passes horizontally inward. These canals are dense and elastic, somewhat dilated at their angles, and have, especially the lower one, some spiral fibres from the tensor tarsi muscle wound round their walls. The *lachrymal sac* occupies the *lachrymal fossa* within the nasal border of the orbit, with the tendo oculi and the tensor tarsi muscle in relation to it anteriorly. Sometimes in distention of the lachrymal sac the tensor projects under the tendo oculi, which occasions a bulging without and within, the tense ligament depressing the top of the sac. The tendo oculi is always the guide to the sac. There are minute valvular folds in the mucous lining of the sac at the entrance of the canals, which is continuous with the conjunctiva through the canaliculi, and with the pituitary membrane of the nose through the nasal duct, the lower constricted portion of the lachrymal sac.

The *ocular portion of the conjunctiva* is very differently arranged in its relations to the sclerotic coat and to the cornea. The *sclerotic conjunctiva* is very loosely attached to the subjacent coat, so as not to interfere with the movements of the eyeball. It is very thin, transparent, and, except when inflamed, nearly colorless. A few scattered blood-vessels extending toward the cornea are generally visible in the healthy condition of the organ; but under the stimulus of a foreign body or of some action upon the vaso-dilator sympathetic nerves, very rapid congestion occurs, through a peculiarly intricate capillary plexus of vessels which is derived from the palpebral and lachrymal arteries.

The laxity of the sclerotic conjunctiva is demonstrated in chemosis, where, owing to the distention, the patient cannot close his eye. The conjunctival vessels are so feebly supported in this loose tissue that they often rupture in paroxysms of whooping-cough or severe vomiting. Conjunctival extravasations are unlike similar conditions elsewhere, and the blood retains its scarlet arterial color, owing to the ready absorption of oxygen from the atmosphere by the blood through the delicate conjunctival membrane. In severe inflammations resulting from burns the mucous lining of the lids

is very often so contracted that the condition of *entropion* is induced. The *corneal conjunctiva* is practically the outer layer of the cornea itself, consisting chiefly of epithelium, and being extremely thin, non-vascular, and transparent. There are numerous lymphatic vessels interspersed through the capillary net-work of the conjunctiva, and the membrane is everywhere extremely sensitive, owing to its abundant supply from the ciliary nerves.

The cornea (pellucida) is the beautiful transparent convex structure projecting from the outer coat of the eyeball, of which it constitutes about one-sixth part. It serves as a circular window by which the light is admitted into the eye. The cornea is composed of four layers of various forms of tissue. The outer layer is the delicate adherent covering of the conjunctiva, already described, which consists of several strata of epithelial cells. Beneath this is the *proper substance* of the cornea, which is fibrous, tough, and perfectly transparent, and upon which the thickness and strength of the cornea depend. The thickness is very deceptive, so that in operating upon the cornea the knife may be thrust among the fibrous laminæ of which it is composed. These laminæ are demonstrable only by the use of reagents. There are some sixty laminæ, the independent fibres of each being arranged in a parallel direction, while those of the alternate laminæ cross at right angles the fibres of the laminæ above and below. In the recent state there is no trace of this complex condition of structure. Interposed between the lamellæ are irregular *spaces* in which are retained the so-called *corneal corpuscles*, which, upon careful inspection under the microscope, appear to intercommunicate. The proper substance of the cornea is continuous with the sclerotic coat, but, owing to the modified character of its connective tissue, in which the elements are so nearly alike in refractive power, in the healthy state it appears homogeneous. Immediately beneath the conjunctival epithelium there is a peculiar lamella, which has been named the *anterior limiting* or *elastic lamina* (*of Bowman*), in contradistinction to the *posterior elastic lamina* (*of Descemet*), which is the posterior modified lamella of the proper substance.

The *posterior elastic lamina* is remarkable for its tendency to curl upon itself, with the corneal surface innermost, when it is separated from the rest

of the cornea. It probably has to do with maintaining the proper curvature of the cornea. The degree of curvature varies in different eyes and at different ages, being more prominent in early life, the cornea gradually flattening with age. The posterior surface of the posterior elastic lamina is covered with a continuation of the *epithelial lining* of the aqueous chamber, which resembles that of other serous membranes. There are no blood-vessels normally within the structure of the cornea. At its circumference the capillaries of the conjunctiva and sclerotic coat terminate in loops. In keratitis these marginal arteries furnish branches which penetrate into the interlamellated spaces. In the affection called pannus the conjunctival arteries send out radiating branches which pass over the cornea through the medium of the somewhat loosened epithelial covering and make it appear to be vascularized, whereas the vessels are entirely superficial and outside of the cornea proper. At birth the cornea is slightly opaque, but shortly afterward becomes transparent. In old age it diminishes in lustre and translucency, especially at the upper and lower borders, where, owing to fatty degeneration at these points, white crescents, forming the *arcus senilis,* appear. It is remarkable that wounds of the cornea heal promptly, in spite of the lack of direct blood-supply. There are very numerous branches from the ciliary nerves which enter the laminated tissue and form minute nerve-plexuses, rendering the cornea ordinarily extremely sensitive. In glaucoma it loses its sensibility, owing to the intra-ocular pressure upon the ciliary nerves before their branches reach the corneal destination. The cornea is set into the anterior border of the sclerotic coat very much as a watch-glass is received into its case, its margin being bevelled on the outside and that of the sclerotic on the inside.

The sclerotic coat is the white, tough, protecting coat of the eye, which maintains the form of the globe, of which it constitutes the outer covering for the posterior five-sixths. It is thickest behind, and thinnest six millimetres, or about a quarter of an inch, from the cornea, where it is apt to be ruptured through violence. This is partly due to the resistance afforded by the recti muscles, which in a measure surround the globe and are inserted into the sclerotic six millimetres, or a quarter of an

inch, from the cornea, leaving the intervening portions of the sclerotic unprotected except by the loose conjunctiva, which gives the brilliant white appearance to the front of the eyeball. The tendons of the recti muscles are exposed by removing the ocular conjunctiva, when they will be seen inserted upon the sclerotic coat in an elliptical manner, so that their central portions approach the cornea more nearly than their sides. This accounts for the unequal division of the tendons in the operation for strabismus unless the whole tendon be hooked forward and completely severed. In the case of the *internal rectus muscle*, which most frequently requires division, this should be especially remembered, as its tendon is nearer to the cornea than that of the others. The origins of the *inferior* and *internal recti* occur at the inner and lower margins of the optic foramen, in the apex of the orbit, from a fibrous band,—the *ligament of Zinn*. The *external rectus muscle* has two heads, the upper one arising from the margin of the optic foramen and the lower one from the ligament of Zinn and the lower border of the sphenoidal fissure. Between these two heads the motor oculi nerve, the nasal nerve, and the abducent nerve pass forward to their distribution, together with the ophthalmic vein. The *superior rectus muscle* arises from the upper margin of the optic foramen and from the dural sheath of the optic nerve. The four recti muscles diverge from their origins and embrace the globe of the eye, being invested with a loose fascia, the *capsule of Tenon* (Plate 5, Fig. 2, No. 6). This fascia consists of two layers with an intermediate space, and thus resembles the tunica vaginalis. There is always a cushion of fatty tissue in the back of the orbit, even when the general state of the individual is one of extreme emaciation, and this cushion takes the shape of a cone, owing to its disposition about the globe of the eye. The prominence of the eyes depends somewhat upon the amount of this fat, and the "hollow-eyed" appearance in old age and in wasting disease is consequent upon its partial absorption. The recti muscles rest upon this orbital fat, and receive sheaths from the ocular layer of the capsule of Tenon, which is closely united with the margins of their tendons. The *ocular layer* of this fascia extends forward to the anterior borders of the orbit, blending with the periosteum, and

Fig 1

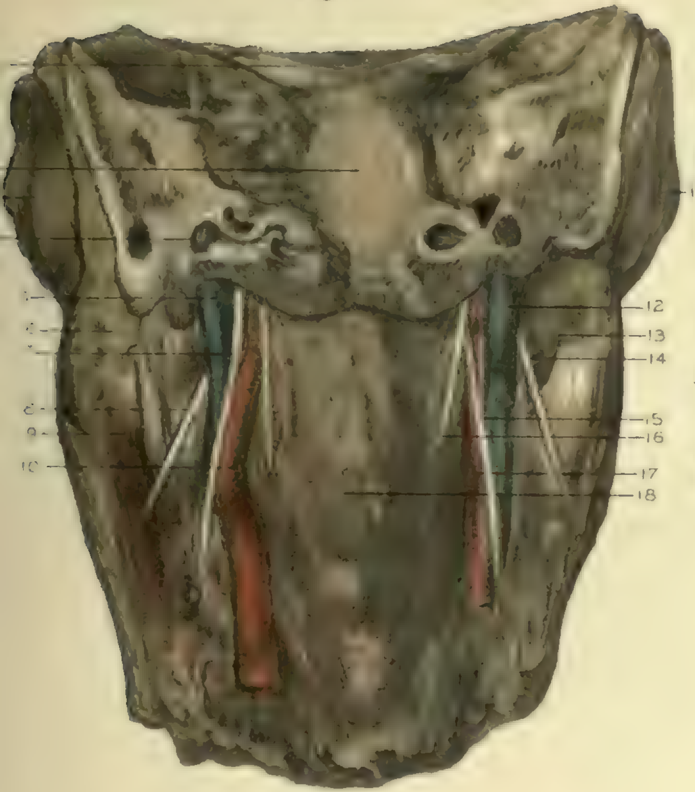


Fig 3

Fig 2

Fig 4

Dissected, Photographed and Colored from Nature by George McClellan, M.D.

Armstrong & Co Lith Boston

especially with the two palpebral ligaments (formerly described). Owing to this intimate relation of the tendons of the recti muscles to their sheaths and the continuation of the latter with the anterior attachments of the capsule, the functional insertion of these muscles is greatly increased. This feature is particularly noticeable in the operation for strabismus, when the fascial connection with the tendon must be completely cut through as well as the tendon itself, or there will still be some counteracting hold upon the globe. In this relation Tenon's capsule is of importance, but much undue stress has been given to it. For the rest, the *outer orbital layer* of the capsule, after sending areolar processes into the interstitial tissue of the fatty cushion, passes backward with the posterior part of the ocular layer to the back of the eyeball, blending with the sheath of the optic nerve. In this locality there is a delicate areolar layer which limits the so-called *perineural space* and allows the ciliary nerves and vessels to pass forward to where they perforate the back part of the sclerotic coat. The *superior oblique muscle*, or *trochlearis*, is a slender muscular ribbon which arises by a tendinous slip in front of and at the inner side of the optic foramen. It passes forward along the roof of the orbit internally to the levator palpebræ muscle, and ends in a rounded tendon, which passes through a fibro-cartilaginous ring, the *trochlea,* which occupies a little fossa within the supra-orbital margin of the frontal bone above the internal angular process. The tendon is provided with a synovial sheath as it passes through the trochlea, whence it is directed beneath the superior rectus muscle and is inserted into the sclerotic coat just without that muscle, midway between the cornea and the entrance of the optic nerve into the eye. The *inferior oblique muscle* is situated in the floor of the orbit, and arises from the orbital plate of the superior maxilla near the lachrymal fossa. It is directed beneath the inferior rectus muscle, to be inserted by a thin tendon at the outer part of the sclerotic coat posterior to the insertion of the superior oblique. The motor oculi nerve supplies the inferior oblique and all the recti muscles, except the external rectus, which receives the abducent nerve. The superior oblique receives the trochlear nerve. The *motor oculi nerve* within the sphenoidal fissure divides into two branches, which pass forward between the two origins of the external

rectus muscle, separated from each other by the nasal nerve. The upper branch, which is the smaller, passes over the optic nerve and supplies the superior rectus and levator palpebræ muscles on their *ocular* borders. The lower branch subdivides into three little nerves, one directed under the optic nerve to supply the internal rectus, and another to the inferior rectus, while the third runs along the floor of the orbit to the inferior oblique muscle. The latter nerve furnishes a small branch to the ciliary ganglion. *Paralysis of the motor oculi* results in a drooping of the upper lid (ptosis), a fixed condition of the eye, with divergent (external) squint from unopposed action of the external rectus muscle, and dilatation and immobility of the pupil. If the paralysis is complete there is apt to be a slight protrusion of the globe in consequence of the relaxation of the recti muscles. The *abducent nerve* also passes forward between the two origins of the external rectus muscle, above the ophthalmic vein, and terminates in fine filaments on the *ocular* border of the external rectus. This nerve carries with it from the cranial cavity some sympathetic fibres from the carotid plexus, and within the orbit it receives other sympathetic fibres from Meckel's ganglion, sometimes a twig from the ophthalmic nerve. *Paralysis of the abducent nerve* results in convergent (internal) strabismus. The *trochlearis nerve* (Plate 5, Fig. 2, No. 2) enters the orbit above the other nerves and crosses the origin of the levator palpebrarum to be distributed to the superior oblique muscle, which it enters upon its *orbital* surface, sending a recurrent branch to the dura mater at the base of the cranium. *Paralysis of the trochlearis nerve* is attended with but little change in the condition of the eye as regards mobility, as the loss of function of the superior oblique muscle may be compensated for by the vicarious action of the other muscles. In all cases of paralysis of the orbital muscles there is more or less diplopia, or double vision. It will be observed from the above that the motor nerves in the orbit enter the muscles upon the ocular surfaces, except the trochlearis, which enters the superior oblique muscle on its orbital surface.

The recti muscles move the eye upward, outward, downward, and inward, according to their position. Acting together they tend to retract the eye, the oblique muscles serving partially to antagonize them. The

superior and inferior recti muscles do not pursue a direct course, but rather one obliquely outward to their insertions, and consequently their independent action in elevating or depressing the eye would be accompanied with some deviation and rotation inward. This is overcome by the peculiar disposition of the oblique muscles, the inferior correcting the action of the superior rectus and the superior correcting the action of the inferior rectus. The independent action of the superior oblique muscle is to rotate the eyeball downward and outward, that of the inferior oblique muscle to rotate the eyeball upward and outward. The ingenious contrivance of these ocular muscles which brings a complete picture before the eye in whatever position the head may be held can best be understood by remembering the *rôle* which the capsule of Tenon plays in blending their tendinous insertions and thereby serving to modify and harmonize their functions.

The *sensory nerves of the orbit* are branches of the ophthalmic division of the trifacial nerve,—viz., the nasal, frontal, and lachrymal nerves. The *nasal nerve,* after passing through the sphenoidal fissure between the two origins of the external rectus muscle, separating the two branches of the motor oculi nerve, as has been stated, crosses over the optic nerve, beneath the levator palpebræ and superior rectus muscles, to the inner wall of the orbit, where, after giving off the infra-trochlear nerve, it leaves the orbit by the anterior ethmoidal foramen. This nerve contributes the *long root* to the *ciliary ganglion* in its passage between the origins of the rectus muscle; also the *long ciliary nerves,* which, passing on the inner side of the optic nerve, receive filaments from the ciliary ganglion and pierce the sclerotic coat to go to the iris. The *infra-trochlear nerve* passes to the inner angle of the orbit, to supply the lachrymal sac, the skin over the inner corner of the eyelids, and the adjacent side of the nose. The *frontal nerve,* the second branch of the ophthalmic nerve, runs along the upper surface of the levator palpebræ muscle, and about the middle of the orbit divides into the supra-trochlear and supra-orbital nerves. The *supra-trochlear* nerve passes above the pulley of the superior oblique muscle to the inner angle of the orbit, where it forms a connecting loop with the infra-trochlear branch of the nasal nerve, and sends a branch

between the orbicular muscle and the orbital arch to supply the skin of the upper eyelid, forehead, and nose (Plate 53, Fig. 1, No. 13). Besides these there are several filaments which penetrate the frontal bone and supply the mucous lining of the frontal sinuses. The *supra-orbital nerve* is really the continuation of the frontal nerve. It passes through the supra-orbital notch or foramen and supplies sensation to the orbicular and occipito-frontalis muscles and the skin of the upper eyelid, forehead, and scalp. The *lachrymal nerve* passes on the outer side of the orbit, above the external rectus muscle, accompanying the lachrymal artery to supply the lachrymal gland. Before entering the gland it gives off a little twig which communicates with the orbital branch of the superior maxillary nerve. In front of the lachrymal gland the nerve pierces the palpebral ligament and supplies the skin at the outer border of the upper eyelid. *Paralysis of the ophthalmic nerve* is attended by loss of sensation in the globe of the eye and the mucous lining and cutaneous surfaces supplied by its branches, a condition which readily exposes the eye to injury.

The *ophthalmic* or *ciliary* (*sympathetic*) *ganglion* is a tiny, reddish-colored, square-shaped body embedded in the orbital fat between the external rectus muscle and the optic nerve in the back of the orbit. It is in close relation to the ophthalmic artery. This ganglion has a *motor root* from the branch of the motor oculi nerve to the inferior oblique muscle, a *sensory root* from the nasal nerve, and a *sympathetic root* from the carotid plexus which joins it with the sensory root. From the anterior border of the ciliary ganglion about a dozen *short*, delicate, ciliary nerves pass forward with the ciliary arteries, in a wavy course, close to the optic nerve, and pass through the back of the sclerotic coat, where they are joined by the *long* ciliary branches from the nasal nerve and are distributed to the ciliary muscle and the iris.

The *ophthalmic artery*, after its origin from the internal carotid artery near the anterior clinoid process of the sphenoid bone, enters the orbit with the optic nerve through the optic foramen. It first holds a position external to the artery, but within the orbit becomes very tortuous, crossing over the optic nerve to the inner side of the orbit, and giving off numerous branches. The first branch of importance is the *arteria centralis retinæ*,

which enters obliquely the outer side of the optic nerve close to the optic foramen and passes forward in the centre of the nerve to the retina. From the ophthalmic, near the above, are given off the *internal* and *external ciliary branches*, the former subdividing in the perineural space into six or seven minute branches, and the latter into as many more, all of which pierce the sclerotic coat. There is a *long* branch of each of these sets, which pass one upon each side of the optic nerve, and, after entering the sclerotic coat, continue between it and the choroid coat toward the iris. On the outer side of the optic nerve, and between the external and superior recti muscles, the *lachrymal artery* arises. It proceeds with the lachrymal nerve to the lachrymal gland, being finally distributed to the neighboring portion of the conjunctiva and eyelids. It also sends a recurrent branch through the sphenoidal fissure, which anastomoses with a branch from the middle meningeal artery. Anterior to the lachrymal artery, the *muscular* branches are distributed to the ocular muscles. The *supra-orbital artery* is a very small vessel which accompanies the supra-orbital nerve in its course and distribution. The *anterior* and *posterior ethmoidal arteries* pass out of the orbit through the ethmoidal foramina, the anterior being accompanied by the nasal nerve. The *palpebral arteries* supply the lids and form arches around their margins by anastomosing with the lachrymal and infra-orbital arteries. The nasal and frontal arteries are the terminal branches of the ophthalmic. The *nasal artery* leaves the orbit above the tendo oculi and joins the angular branch of the facial on the nasal side of the eye. The *frontal artery* inosculates with the supra-orbital artery at the inner angle of the eye. There are two *ophthalmic veins*, which convey the venous blood from the orbit to the cavernous plexus around the internal carotid artery. The *superior ophthalmic vein* commences at the inner angle of the eye, where it communicates with the frontal and angular veins. Thence it passes along the inner and upper part of the orbit, receiving tributary veins which correspond to the arteries with which they are in relation. The *inferior ophthalmic vein* receives the blood from the outer and lower part of the orbit and passes along the floor to empty into the superior vein, or directly into the cavernous plexus.

The optic nerve, from the optic foramen to its entrance at the back

of the globe of the eye on the nasal side of its axis, is about two and one-half centimetres, or an inch, in length. It is enveloped by a double sheath, consisting of a prolongation of the pia mater within and of the dura mater without. The dural sheath is firm and fibrous, and is continuous with the sclerotic coat, and at the optic foramen it also blends with the periosteum of the orbit from which the ocular muscles arise. The optic nerve is surrounded by the *perineural space*, formed by the inflection of the orbital fascia, already mentioned, in which the ciliary vessels and nerves pass forward. The orbital fat separates it from the recti muscles. It is pierced on its outer side, near the optic foramen, by the *central*, or *retinal, artery*, which, with its vein, passes forward in a central canal made up of processes from the pial sheath.

The eyeball is composed of three concentric coats,—an *outer* fibrous, strong, and protective coat, consisting of the *sclerotic* and *cornea;* a *middle* or vascular coat, composed of blood-vessels, muscular tissue, and dark pigment cells, and consisting of the *choroid*, the *iris*, and the *ciliary processes;* and an *inner* or nervous coat, the *retina*, which is the expansion of the optic nerve. Within these there are three transparent media for the transmission of light,—viz., the *aqueous humor* in front, the *crystalline lens* in the middle, and the *vitreous body* behind. The optic nerve becomes slightly constricted as it approaches the sclerotic coat, and breaks up into a number of bundles of fibres, which pass through minute apertures in the sclerotic coat, giving a cribriform character to this portion of the membrane, which is therefore called the *lamina cribrosa*. The *porus opticus* is the central and largest of these apertures, and transmits the retinal vessels. Around the cribriform lamella there are many puncta for the transmission of the ciliary vessels and nerves. The *anterior ciliary arteries*, which are derived from the muscular arteries of the orbit, run along the tendons of the recti muscles, pierce the sclerotic coat very near the cornea, and form the circular anastomosis of the iris. There is a small oval canal running round the corneal attachment of the sclerotic, the *sinus circularis iridis*, or *canal of Schlemm* (or *Fontana*). At the junction of the *posterior elastic lamina of the cornea*, or *Descemet's membrane*, already described, with the sclerotic coat on its *inner* surface, it spreads out

into a circle of radiating processes,—the *ligamentum pectinatum iridis,*—some of which are attached to the front of the iris at its circumference and others to the anterior part of the sclerotic and choroid coats. The intervals between these processes are called the *spaces of Fontana,* and these communicate with the canal of Schlemm, conveying the fluid of the anterior chamber into it.

The choroid coat is the soft vascular tunic which underlies the sclerotic coat, and the space between the two is traversed by a mesh-work of connective-tissue fibres containing stellate pigment cells, the *suprachoroid membrane.* The connective tissue which underlies the sclerotic coat and unites it with the choroid is called the *lamina fusca,* and the contiguous surfaces of these two layers of tissue are lined with epithelium, having a *lymph-space* between them which is in reality continuous with that of the capsule of Tenon, through the prolongation of that fascia accompanying the ciliary vessels and nerves. Into this lymph-space hemorrhage may occur in injuries to the globe of the eye, and the same occurrence sometimes follows the operation of iridectomy or of extraction of cataract, owing to the sudden diminution of ocular tension. The choroid coat is deficient posteriorly where the optic nerve enters, but from this point to the iris anteriorly it consists of two layers,—the *outer* one containing principally large plexuses of veins, the *venæ vorticosæ,* and the *inner* one being composed of a net-work of capillaries from the long and short ciliary arteries, the *tunica Ruyschiana.* The veins of the outer coat of the choroid present remarkable regularity in their arrangement, and converge to five or six equidistant trunks, which, after piercing the sclerotic coat at the outer side of the lamina cribrosa, terminate in the ophthalmic veins. Between the veins run forward the choroid arteries, consisting of the anterior ciliary arteries, which come from the muscular arteries of the orbit entering anteriorly, and the long and short posterior ciliary arteries, entering around the optic nerve. Interspersed between the vessels are dark *pigment cells* which communicate with one another by fibrous prolongations and constitute a delicate net-work. The inner layer of the choroid, which is formed by the radiating capillaries from the choroid arteries, is the most delicate vascular net-work found in any tissue. On the

PLATE 14.

Figure 1.

Transverse section of the neck of a negro (male), aged thirty years. From the fifth cervical vertebra behind to the cricoid cartilage in front.

1. The spinous process of the fifth cervical vertebra.
2. The left transverse process of the fifth cervical vertebra.
3. The left vertebral artery and vein.
4. The body of the fifth cervical vertebra.
5. The left vagus nerve (or pneumogastric nerve).
6. The left common carotid artery.
7. The œsophagus.
8. The left internal jugular vein.
9. The left lobe of the thyroid body.
10. The rima glottidis, seen through the cricoid cartilage.
11. The left external jugular vein.
12. The hoop of the cricoid cartilage in front.
13. The right trapezius muscle.
14. The right complexus muscle.
15. The medulla spinalis.
16. The right transverse process of the fifth cervical vertebra.
17. The right vertebral artery and vein.
18. The longus colli muscle.
19. The right vagus nerve (or pneumogastric nerve).
20. The right common carotid artery.
21. The right internal jugular vein.
22. The right lobe of the thyroid body.
23. The right omo-hyoid muscle.
24. The right external jugular vein.
25. The sterno-thyroid and sterno-hyoid muscles.

Figure 2.

Transverse section at the root of the neck (same as Figure 1) from the first dorsal vertebra to the top of the sternum.

1. The cut cords of the right brachial plexus of nerves.
2. Section through the apex of the right lung.
3. The right innominate vein.
4. The right vagus nerve.
5. The innominate artery.
6. The sternal end of the sterno-mastoid muscle.
7. The trachea.
8. The sterno-thyroid and sterno-hyoid muscles.
9. The recurrent laryngeal nerve.
10. The œsophagus.
11. The left common carotid artery.
12. The left vagus nerve.
13. The left innominate vein.
14. The left subclavian artery.
15. The left scalenus anticus muscle.
16. The supra-scapular artery and vein.
17. The right scalenus anticus muscle.
18. The right transverse process of the first dorsal vertebra.
19. The head of the right first rib.
20. The medulla spinalis.
21. The spine of the first dorsal vertebra.
22. Section through the intervertebral disk.
23. The left transverse process of the first dorsal vertebra.
24. The apex of the left lung.
25. The splenius muscle.
26. The trapezius muscle.

N. B.—These sections were made on a recent well-developed cadaver, placed in the horizontal position, without any freezing or hardening agent, and the plates represent the relations of the parts absolutely as they were.

Fig 2

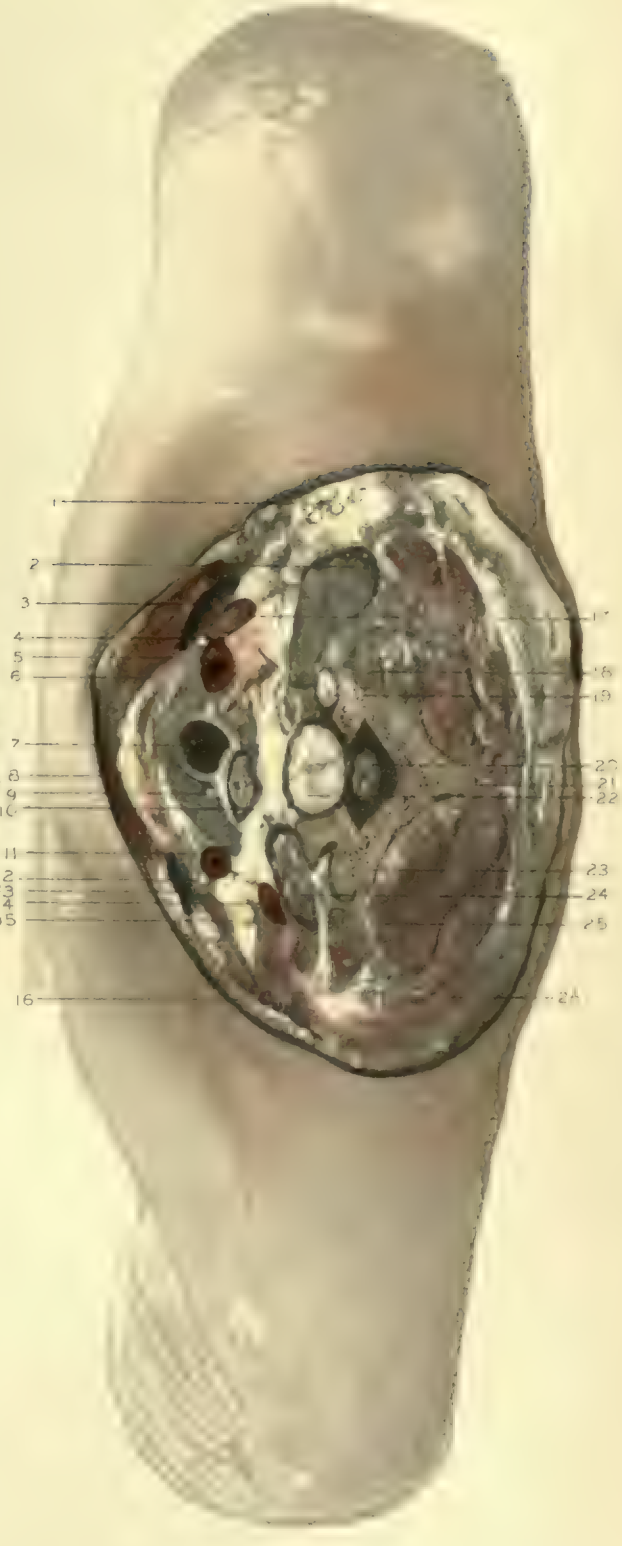
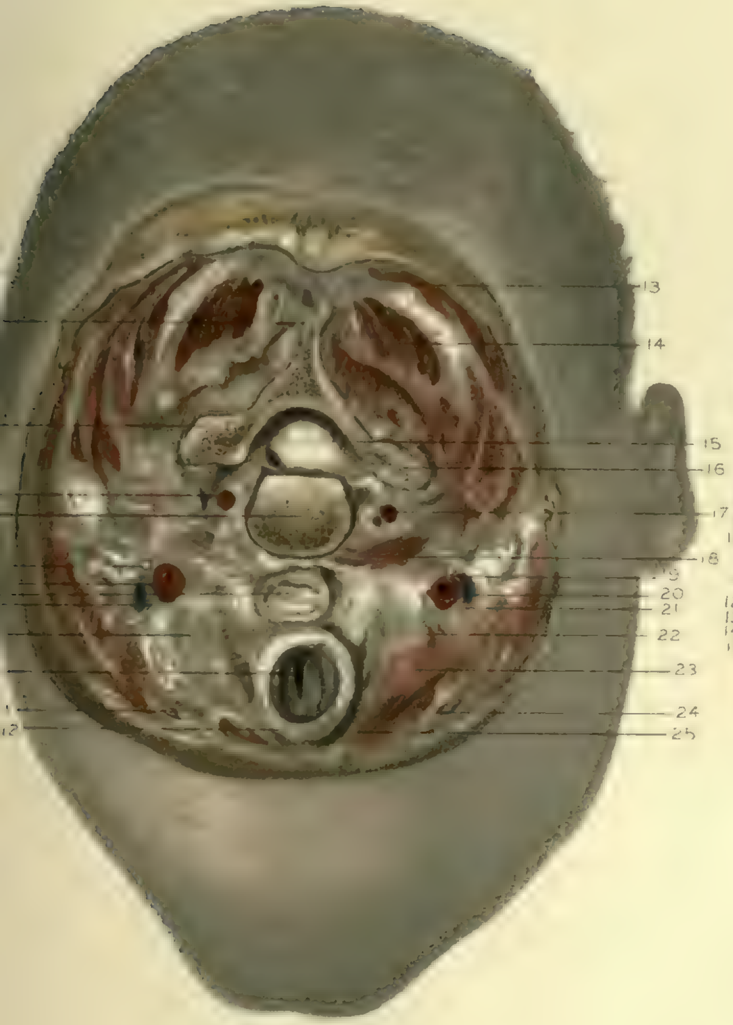


Fig 1



... and Colored from Nature ... George McClellan M.D.

inner surface of this vascular tissue is a very thin membrane, the *lamina vitrea*, which separates it from the pigmentary layer of the retina. The choroid coat splits anteriorly into the ciliary muscle in front and the ciliary processes behind, both constituting the *ciliary body*. The ciliary processes consist of about seventy large and small, alternating, plaited folds of the tissues of the choroid, with their vessels, nerves, and pigment. They are arranged radially behind the ciliary muscle and the iris, and posteriorly fit into corresponding folds of the suspensory ligament of the lens, especially into the part called the *zone of Zinn*, and their rounded free ends, which are devoid of pigment, project a little distance into the posterior chamber, and rest upon the capsule of the lens.

The *ciliary muscle* is a zone of unstriped muscular fibres at the front of the choroid coat, arising close to the canal of Schlemm, at the junction of the sclerotic coat and the cornea. Some of the fibres radiate backward and blend with the ciliary processes, and others form the *circular ciliary muscle* (or *ciliary ligament*) around the periphery of the iris. Its action is to accommodate the eye to objects at various distances, which it probably accomplishes by drawing on the ciliary processes and thus relaxing the suspensory ligament of the lens, rendering the anterior surface of the lens more convex. The nerves supplying the ciliary muscle are derived from the long and short ciliary nerves. The ciliary region is the *dangerous area of the eye*, owing to its important vascular and nerve anastomoses and its relations to the cornea, iris, choroid coat, retina, and vitreous body. Wounds of the cornea in front of this region, or of the sclerotic coat behind it, are not so hazardous, but any traumatic affection of the ciliary body is liable to be followed by the gravest results. Not only are the contiguous parts readily involved by the spread of inflammation from this locality, but experience has shown that that terrible affliction called *sympathetic ophthalmia*—whatever may be the insidious and latent process by which it travels from one eye to the other—invariably has its origin in some injury to the ciliary region.

The iris (a rainbow), so called from its various colors in different individuals, is the continuation of the ciliary muscle. It is a circular contractile membrane, with a round hole a little to the inner side of its

centre, the *pupil,* and hangs like a curtain in the aqueous humor behind the cornea and in front of the ciliary processes and the lens. The iris divides the space occupied by the aqueous humor into the *anterior* and *posterior chambers,* which communicate through the pupil. It is connected with the choroid coat at its circumference through the ciliary muscle, and by the ligamentum pectinatum (already described) with the cornea. Its connection, however, with these parts is not very close, for the iris is sometimes torn from its attachments in contusions, without serious injury to the adjacent structures. Its yielding nature is taken advantage of in the operation of iridectomy, when the piece of the iris to be excised is readily drawn through the corneal incision. At the pupillary border it rests lightly upon the lens, and consequently when inflamed, as in iritis, it may become attached to the latter. The coloring-matter of the iris is due to minute *pigment cells* upon its surfaces, the posterior radially-furrowed surface being called the *uvea,* from its ordinary grape-like color. The color of different eyes depends upon the disposition of the pigment cells in their irides. In blue or light-colored eyes the pigment is upon the uvea, or posterior surface, and is modified by being seen through the texture of the iris, whereas in dark eyes the pigment is upon both surfaces. The iris consists of connective tissue and unstriped muscular fibres, and serves as a diaphragm to the eye, by which the amount of light passing through the pupil to reach the retina is regulated.

The fibres of the connective tissue are arranged longitudinally and circularly, the former radiating toward the pupil, having between them the vessels and nerves, and the latter surrounding its attached border. The pigment cells are intermingled in the meshes of the connective tissue. The muscular fibres are also longitudinal and circular. The longitudinal muscular fibres, constituting the *dilatator pupillæ,* form a very thin layer of radiating fibres, which converge from the circumference toward the pupil, where they are inserted into the *sphincter pupillæ,* which consists of well-marked circular muscle-fibres on the posterior surface of the margin of the pupil. Only the latter are clearly demonstrable in the human eye. The size of the pupil varies, according as the muscular fibres are contracted or relaxed, from one and one-fourth to eight and

one-half millimetres, or from one-twentieth to one-third of an inch. During the first seven months of fœtal life the pupil is closed by a transparent vascular membrane, the *membrana pupillaris*, which until that period completely separates the anterior and posterior chambers from each other. About the eighth month this membrane is gradually absorbed, there being very little trace of it left normally at birth. The iris is supplied by the two long ciliary arteries and the anterior ciliary arteries. The long ciliary arteries (described in connection with the choroid coat) near the attached border of the iris divide into upper and lower branches, which anastomose with each other and the anterior ciliary arteries, forming the *circulus major* of the ciliary muscle, from which two sets of small branches are given off, one to supply the muscle, and the other converging toward the pupil and forming the *circulus minor* of the iris. The latter gives off numerous capillaries which terminate in *veins*, and they in turn empty into the canal of Schlemm. The nerves of the iris are non-medullated fibrils continued from the nerves in the ciliary muscle, where they form a plexus. Originally they are derived from the long ciliary nerves, from the nasal branch of the ophthalmic nerve, and from the dozen or more branches from the *ciliary ganglion*, which, as already described, has a motor root from the motor oculi nerve, a sensory root from the nasal nerve, and a sympathetic root from the carotid plexus. Although the nervous distribution to the iris is of a very complex character, owing to this diversity of origin of the fibres composing the ciliary nerves, it is believed that the circular fibres (sphincter) of the iris are chiefly supplied by the motor fibres from the motor oculi nerve, while the radiating fibres (dilatator) are supplied merely by the sympathetic filaments, possibly inhibitory. The motor fibres and sympathetic fibres appear to exercise an antagonistic influence upon the pupil, as experiment has shown that division of the motor oculi nerve is followed by dilatation and that of the sympathetic by contraction of the pupil. The sensibility of the iris, as well as of the cornea, is due to the filaments derived from the nasal nerve. The accommodation of the eye for vision at long or short distances, with the object exposed in a bright or a dim light, requires a degree of perfectness in the regulating apparatus to which

the iris greatly contributes. It has been stated (page 100) that the circular fibres are the most marked in the human iris; and the many changes to which they are subjected are probably due to the influence of the *vaso-motor* sympathetic ciliary nerves on the capillary vessels of the iris, for not only does the influence of the light upon the retina incite by reflex action a corresponding degree of contraction or dilatation of the pupil according to its intensity, the impression probably being transmitted through the optic nerve to the optic lobes in the brain and thence to the motor oculi nerve and its continuations, but there are other conditions with which the light has nothing to do. The pupil is always observed to be dilated in coma, from compression of the brain in many states of shock, in many mental or nervous derangements, and in the general relaxation of the muscular system at the moment of death. One of the physiological actions of belladonna, which seems to paralyze the vaso-motor nerves, is to dilate the pupil. Opium, on the contrary, by increasing the tension of the capillaries, induces contraction of the pupil.

The aqueous humor consists of a few drops of clear limpid alkaline fluid, which fills the space between the cornea and the lens in which the iris is suspended, dividing the space, as already mentioned, into the anterior and posterior chambers. The *posterior chamber* is a very small angular interval between the back of the iris and the ciliary processes and the suspensory ligament and the capsule of the lens. The *anterior chamber* is in communication with the canal of Schlemm—the circular venous canal at the junction of the cornea with the sclerotic coat—through the spaces of Fontana. This canal therefore brings the anterior chamber into relation with the venous circulation, and thus the ready absorptive power of the aqueous humor may be explained,—as is proved in the speedy removal of extravasated blood, or in the treatment of soft cataract by the "needle operation." The aqueous humor is also rapidly secreted after the extraction of a cataract.

The crystalline lens is a perfectly translucent, biconvex, semi-solid body placed immediately behind the pupil, and completely surrounded by an equally translucent elastic capsule. The *capsule of the lens* resembles the elastic lamina of the cornea, and is thicker in front than behind. The

anterior surface of the capsule is in contact with the free pupillary margin of the iris. There is no vascular connection between the lens and its capsule, but the capsule is separated from the front of the lens by a layer of epithelium which after death exhales the so-called *liquor Morgagni.* The capsule is retained in its position by the *suspensory ligament of the lens*, or the *zone of Zinn,* which is the continuation of the hyaloid membrane, extending from the vitreous body to the ciliary processes. The elasticity of the capsule is manifest from the curling outward of its edges in lacerated wounds, or in cataract operations. When the capsule is wounded the aqueous humor is imbibed by the fibres of the lens to a greater or less degree, with proportionate opacity.

The *lens* consists of three triangular segments, which are composed of numerous concentric layers. It is somewhat soft and gelatinous externally, but each successive layer becomes more dense toward the centre, which is hard and is called the *nucleus.* The laminæ consist of minute parallel fibres which are hexagonal prisms fitting accurately into one another by a dovetailing of their edges. The lens varies with age and the conditions of myopia and presbyopia. In early life it is almost spherical, but in old age it becomes flattened, yellowish, and less transparent. In the adult it is distinctly more convex behind than in front. The function of the lens is to bring the rays of light coming from any object to a focus upon the retina. The *canal of Petit* is the so-called encircling space between the capsule of the lens and its suspensory ligament, formed by a splitting of the latter. It probably contains a semi-fluid extension of the vitreous humor; when inflated by a blow-pipe it presents a peculiar beaded appearance, owing to the plaiting of the suspensory ligament on the front of the lens.

The vitreous body is the transparent jelly-like substance filling the cavity of the retina, immediately behind the lens, which it accommodates in front in a depression (the *hyaloid fossa*) adapted to its capsule. It is surrounded, except in front, by the delicate, transparent *hyaloid membrane,* which, as already explained, passes forward anteriorly to form the suspensory ligament of the lens. The latter portion of the hyaloid membrane contains longitudinal elastic fibres. The vitreous body consists of a fluid contained in cellular meshes which freely intercommunicate, as is seen in

PLATE 15.

Anterior view of the muscles of the face of a well-developed man, aged thirty-five years, showing the delicate interlacing of the fibres about the corners of the eyelids and mouth. This dissection was made with especial care to demonstrate the anatomy of expression in its application to the facial markings now considered characteristic of disorders pertaining to mental, nervous, digestive, and respiratory functions.

1. The epicranial aponeurosis or (*galea capitis*).
2. The right frontal muscle.
3. The external lateral fibres of the right frontal muscle, some of which are attached to the external angular process of the orbit, and others blend with the adjacent orbicularis muscle.
4. The pyramidal slip from the frontal muscle descending upon the nasal bone.
5. The right temporal aponeurosis.
6. The right orbicularis palpebrarum muscle.
7. The right compressor naris muscle.
8. The right levator labii superioris et alæ nasi muscle.
9. The right levator labii proprius muscle.
10. The right levator anguli oris muscle.
11. The depressor alæ nasi muscle.
12. The depressor septum nasi muscle.
13. The right zygomatic muscle.
14. The superior labial portion of the orbicularis oris muscle.
15. The right masseter muscle.
16. The inferior labial portion of the orbicularis oris muscle.
17. The triangular, or depressor anguli oris (labii inferioris) muscle.
18. The right levator menti muscle.
19. The quadratus, or depressor labii inferioris proprius muscle.
20. The inter-frontal aponeurosis.
21. The peculiar looping of the fibres of the frontal muscle.
22. The transverse fibres of the orbicularis palpebrarum muscle, which arise from the internal angular process of the orbit, called the *corrugator supercilii* muscle.
23. The left pyramidalis nasi slip from the frontal muscle.
24. The interlacing of the fibres of the frontal with the orbicularis at the inner corner of the eyelid.
25. The tendo oculi.
26. The left compressor naris muscle.
27. The left orbicularis palpebrarum muscle.
28. The left levator labii superioris et alæ nasi muscle.
29. The left levator labii superioris muscle.
30. The left levator anguli oris muscle.
31. The left zygomaticus muscle.
32. The left buccinator muscle (just seen in this view).
33. The left masseter muscle.
34. The left depressor anguli oris muscle.
35. The left depressor labii inferioris muscle.
36. The left levator menti muscle.

N. B.—The platysma muscles have been removed from their attachment at the outer corners of the mouth, where they form the laughing muscles of Santorini. The vessels and nerves have also been removed, as they are shown in other plates, in order to give a clearer idea of the interdependence of the facial muscles.

Dissected, Photographed and Colored from Nature by George Mc Clellan, M.D.

Armstrong & Co. Lith Boston

puncture of the body, when the humor drains away. There is a *central canal* (*of Stilling*) which passes from the position of the entrance of the optic nerve to the middle of the back of the capsule of the lens: it is lined by a prolongation of the hyaloid membrane, and contains fluid. In the fœtus this canal conveys the little hyaloid artery from the central artery of the retina to the capsule of the lens. On the inner side of the hyaloid membrane there are many granular corpuscles, which under the microscope exhibit amœboid movements. The *muscæ volitantes* which often trouble short-sighted persons are due to opaque matters suspended in the vitreous body, and closely resemble the hyaloid corpuscles.

The retina is the delicate nervous membrane formed by the expansion of the optic nerve after its passage through the sclerotic and choroid coats, upon which the images of external objects are received. It is the so-called inner coat of the eye, and is placed between the choroid and the hyaloid membrane, extending as far forward as the ciliary ligament, where it terminates in a fine serrated border,—the *ora serrata*,—a single lamina of its tissue, the *pars ciliaris*, being continued to the ciliary processes and the iris. The retina is thickest at the entrance of the optic nerve, and gradually becomes thinner toward the ora serrata. Its internal (hyaloid) surface is smooth, and during life appears as a transparent pinkish tissue. At the point of entrance of the optic nerve there is a round disk, called the *porus opticus*, in the centre of which may be seen with the ophthalmoscope the central artery of the retina entering and branching above and below, and the central veins converging and passing inward. There is also a little prominence of the nerve-substance at this point, the *optic papillæ.* This prominence is sometimes called the *blind spot* (or *punctum cæcum*), because it is altogether insensible to the rays of light. In the recent state, at the fundus of the eye, directly opposite the pupil, in the centre of the axis of vision, there is an oval, yellow spot (*macula lutea*) in the retina, with a central conical pit, the *fovea centralis.* Here the structure is so thin that the dark pigmentary layer of the retina (the *tapetum*) is seen through it, and it is at this point that the impression of light is greatest and vision is considered to be most perfect.

The *porus opticus* is about two and one-half millimetres, or one-tenth

of an inch, to the *inner* side of the macula lutea. After death there is a minute transverse fold in the retina extending from the centre of the fovea to the papilla. The *retina* appears to the naked eye as a simple, soft, transparent membrane, but when examined under the microscope it is found to be an exceedingly complex structure, showing the most elaborate organization. It is composed of *eight* layers, all differing from one another, arranged in strata, and supported by an extremely delicate connective-tissue framework (the *sustentacular tissue*), which upon the choroid and vitreous surfaces becomes somewhat condensed and appears membranous, forming respectively the so-called *membrana limitans externa* and *membrana limitans interna.* The first, outer, or pigmentary layer, the *tapetum nigrum* of the retina, is a layer of hexagonal epithelial nucleated cells, containing pigment granules only on their *inner* portions, which, although in the closest relation with the choroid coat, are prolonged like fine tapering filaments between the numberless elongated bodies of the second layer. The pigment is probably so disposed to absorb the rays of light, and thus, preventing its reflection, to convert it into some form of nervous force. The second or columnar layer is composed chiefly of minute, bacillus-like bodies, which penetrate externally into the pigmentary layer and internally into the subjacent outer nuclear layer, being supported by a trabecular arrangement of the connective tissue (the membrana limitans externa). These bodies are also known as the *rods* and *cones,* the former being club-shaped and greatly outnumbering the cones, which are flask-shaped and isolated and scattered among the rods. The rods are longer and therefore more in relation with the pigmentary layer, while the cones are shorter; and they are both connected with the subjacent outer nuclear layer by delicate fibrous prolongations. The rods are not found in the yellow spot. Little is known regarding the function of these interesting little bodies beyond the facts of comparative anatomy that among those animals and birds which seek their food by night the retina consists solely of rods, and that in the case of birds which live on brightly-colored insects the cones are about as numerous as the rods. From these facts the inference is drawn that the rods are concerned in the discrimination of the quantity of light, the cones in that of its

quality or color. The next succeeding four layers are alternating *nuclear* and *molecular* layers, called *outer* and *inner*, from their relative positions. They consist of strata of clear nucleated corpuscles or granules, modified in each layer so as to offer some peculiarities, and embedded in the retinal connective tissue. They are severally connected by upward and downward prolongations, the outer nuclear layer with the rods and cones as above stated, whereas the inner molecular layer joins the seventh or ganglionic layer. The last is a very clear stratum of spheroidal nerve-cells connected by oblique processes with the eighth retinal layer, which consists of the ultimate fibres of the optic nerve. The ganglionic cells are inserted into several strata in the vicinity of the yellow spot, and within it into six or seven. The layer of nerve-fibres is composed of the axis cylinders only, and is continued as far forward as the ora serrata, arranged for the most part in bundles which interchange so as to form plexuses. At the yellow spot this layer is interrupted by the accumulation of nerve-cells.

THE REGION OF THE NOSE AND THE NASAL CAVITIES.

The special organ of the sense of smell consists of an external portion, the *nose*, and internal portions, the *nasal fossæ*, or *nasal cavities.*

The nose is the prominent feature which projects anteriorly between the orbits from the upper part of the face, being connected by its summit with the forehead and by its base with the upper lip. It serves as the chief avenue of respiration when the mouth is closed. The skeleton of the nose consists of the two nasal bones and the nasal processes of the superior maxillary bones, to which is attached a cartilaginous framework composed of five peculiarly-shaped movable cartilages.

The *nasal bones* are severally of an elongated quadrilateral shape, being narrow and thick above, where they are firmly attached by suture with the nasal spine of the frontal bone, constituting the *nasion*, and wide and thin below, where they form the upper margin of the *anterior nasal fossæ of the skull* (Plate 28) and in the recent state give attachment to the upper

lateral nasal cartilages. They are strongly united in the middle line, forming "the bridge" of the nose, this juncture being strengthened by their inner borders projecting as a longitudinal *crest,* which connects them with the ethmoidal portion of the septum of the nose. Their outer borders are bevelled, and supported by the contiguous borders of the superior maxillary bones. The width and length of the nasal bones vary greatly in different skulls, and, as they are almost immediately beneath the skin (Plate 1), they give shape and character to the organ. The under surfaces of the nasal bones are grooved for the nasal nerves, and perforated by a few small foramina for the transmission of vessels.

The *nasal processes of the superior maxillary bones* are triangular, thick, bony plates which extend upward on each side of the nose to be joined by suture with the frontal bone. Their anterior borders are serrated for articulation with the nasal bones,—the form and dimensions of the nose being mainly dependent upon the development of these processes and the manner in which the nasal bones are set upon them. The outer surfaces of the nasal processes are serrated and concave; the internal surfaces are rough, and present two well-marked ridges, the superior and inferior turbinated crests, the former articulating with the middle turbinated portion of the ethmoid bone and the latter with the inferior turbinated bones on each side.

The *cartilaginous framework of the external nose* is formed of a median septum and two lateral segments on both sides. The *cartilage of the septum* is a smooth triangular plate inserted posteriorly into a groove in the perpendicular plate of the ethmoid bone; anteriorly, where it is thicker, it is connected above with the nasal bones and adjacent lateral cartilage, and below with the vomer and the palatine processes of the superior maxillary bones. The septal cartilage separates the anterior portions of the nasal cavities, and up to the seventh year of age is usually straight, but subsequently it is apt to incline to one side (usually the left), according to the deviation of the vomer (Plate 28, No. 39). Sometimes it is perforated, and thus establishes a communication between the cavities. The *lateral cartilages* consist of an *upper* triangular piece and a *lower* oval piece on each side, which together give shape to the wings and tip

of the nose and support the integument. Each upper cartilage is attached above to the margin of the nasal bone and adjoining nasal process, in front to the septum, and below to the lower cartilage. The latter is curved upon itself so as to form the outer and inner boundaries of the external orifice of the nostril. It approaches its fellow of the opposite side internally, and thus forms the upper part of the *columna nasi*, the partition between the nostrils. When the lower lateral cartilages are not in contact there is a median furrow which is sometimes well marked at the tip of the nose. These cartilages are connected to each other and to the bones by a tough fibrous membrane, the *perichondrium*. In this tissue, in relation to the superior maxillæ, there are usually several nodules,—*sesamoid cartilages*. The elasticity of these cartilages preserves the size and shape of the nostrils, and enables the muscles moving them to expand or contract the orifices so important in respiration. The *skin* over the root of the nose below the forehead, on the sides and the greater part of the dorsum, is thin and loose; but over the wings (*alæ*) and on the point it is thick and very adherent to the parts beneath, and remarkable for the number and size of its sebaceous follicles. Owing to the presence of the latter, the lower part of the nose is frequently the seat of acne. Inflammation of the skin over the cartilaginous portion of the nose is very painful, and is usually accompanied by local congestion, the pain depending upon the tenseness of the part and the congestion upon the free blood-supply of the region. There is very little fat in the cellular tissue between the skin and the alar cartilages.

The muscles in connection with the nose are, on each side, the pyramidalis nasi, the compressor naris, the depressor alæ nasi, and the smaller dilatator muscles. The *pyramidales nasi muscles* arise from the upper borders of the right and the left compressor naris muscle, having an angular interspace between them, and pass upward over the bridge of the nose, joining each other in the middle line, and blending their outer fibres with the orbicular muscles of the eyelids, their inner fibres being prolonged into the occipito-frontales muscles (Plate 15, No. 4). The principal action of these muscles is to produce transverse wrinkles at the root of the nose, by drawing down the inner angles of the eyebrows;

but by reversing their action and tightening the skin over the alar cartilages they may also serve as dilators of the nostrils. The *compressor muscles* of the nose are triangular in shape, arising on each side of the face, from the inner sides of the canine fossæ of the superior maxillæ, and join by a common aponeurosis over the dorsum of the nose. These muscles compress the alæ and produce the pinched appearance seen in labored breathing. Their origins are concealed by the elevator muscles of the upper lip and the wing of the nose (Plate 18, No. 4, and Plate 19, No. 5).

The *depressores alarum nasi muscles* arise from the superior maxillary bones, above the second incisor teeth, and, being placed between the mucous lining of the upper lip and the orbicular muscle of the mouth, their fibres radiate to the septum and back parts of the alæ of the nose. These muscles serve to constrict the anterior nares by drawing the alæ downward.

The *dilatator—anterior* and *posterior—muscles* are very delicate bundles of fibres, which pass respectively from the alar cartilage to the overlying skin, and from the sesamoid cartilages and nasal process of the superior maxilla to the margin of the nostrils. In ordinary respiration, especially in sleep, these little muscles resist the tendency of the nostrils to close from atmospheric pressure, by raising and everting the alæ, but in dyspnœa their action is marked, as it also is in the expressions of pride, anger, and disdain.

The *arteries* of the nose are the *lateralis nasi* from the facial (Plate 18, No. 6), the nasal branch from the superior coronary artery to the septum, and the nasal branches from the ophthalmic and infra-orbital arteries. The great vascularity of the skin over the nose renders it well adapted for plastic surgery in this region. The *nasal veins* empty into the facial and ophthalmic veins. The *nerves of the nose* are branches from the facial nerve which supply the muscles, branches from the infra-orbital and infra-trochlear nerves, and the *naso-lobular* filament from the nasal branch of the ophthalmic, which, after descending in a groove on the inner surface of the nasal bone, becomes subcutaneous at the junction of the nasal bone and upper lateral cartilage and supplies the tip and lobule of the nose (Plate 53, Fig. 1, No. 17). This latter nerve establishes connections with the eye, as is demonstrated by the lachrymation which follows

any intense irritation about the nostrils. There are numerous lymphatic vessels about the nose, which follow the course of the facial vein and mostly empty into the lymphatic glands of the submaxillary region (Plate 16). Within the margins of the nostrils there are numerous stiff curved hairs, *vibrissæ*, which grow from the inner surface of the alæ and septum as far as the place where the skin joins the mucous lining of the nasal cavities.

The nasal fossæ, or **nasal cavities**, are the two very irregularly shaped air-chambers, separated by the septum nasi, which open on the face by the *anterior nares* and on the pharynx by the *posterior nares*, and communicate at their outer sides with the sinuses of the ethmoid, sphenoid, frontal, and superior maxillary bones. They also communicate with the orbits by the lachrymal canals, with the mouth by the anterior palatine canals, and with the cranium by the olfactory foramina. Each nasal fossa is narrower above than below, and higher at the centre than at either the anterior or the posterior opening. The roof of each nasal fossa is formed by the nasal bone, the nasal spine of the frontal bone, the cribriform plate of the ethmoid bone, the body of the sphenoid bone, and the sphenoidal turbinated bones. The floor is formed by the horizontal plates of the superior maxillary and palate bones, and is wider at the centre than at either end. The inner wall is the smooth septum formed principally by the perpendicular plate of the ethmoid bone, the vomer, and the septal cartilage. The outer wall is formed by the nasal processes and inner surfaces of the superior maxillary, lachrymal, ethmoid, palate, and inferior turbinated bones, and the internal pterygoid plate of the sphenoid bone. The *turbinated bones* are delicate, spongy, scroll-shaped bony shelves, which give greater extent of surface to the mucous lining of the nose, projecting from the outer wall and dividing each nasal cavity into the *superior*, *middle*, and *inferior nasal meatuses*, or passage-ways (Plate 12, No. 29). The *superior meatus* is the smallest, and occupies the upper and back part of the nasal fossa, between the superior and middle turbinated bones. In the dried skull the spheno-palatine foramen opens at the back part of the outer wall of the superior meatus, but in the recent state this opening is covered by the pituitary mucous membrane. The *posterior ethmoidal cells* communicate with the superior meatus imme-

PLATE 16.

Dissection of the superficial muscles of the right side of the head, face, neck, thorax, and arm. From a well-developed male, aged thirty-five years. The superficial lymphatic glands and vessels of the face and neck are drawn on the photograph (after notes of many dissections) to show their arrangement and position.

1. The epicranial aponeurosis.
2. The temporal muscle, with the temporal lymphatic vessels.
3. The posterior auricular lymphatic glands.
4. The superficial jugular lymphatic glands.
5. The mastoid attachment of the sterno-cleido muscle.
6. The occipital lymphatic glands and vessels.
7. The splenius muscle.
8. The levator anguli scapulæ muscle.
9. The scaleni muscles.
10. The trapezius muscle.
11. The deltoid muscle.
12. The compressor naris muscle.
13. The buccinator muscle.
14. The anterior auricular lymphatic glands.
15. The supra-parotid lymphatic glands.
16. The masseter muscle.
17. The depressor anguli oris muscle.
18. The submaxillary lymphatic glands.
19. The digastric muscle.
20. The hyoid bone.
21. The thyro-hyoid muscle.
22. The omo-hyoid muscle.
23. The pomum Adami of the thyroid cartilage.
24. The carotid lymphatic glands.
25. The sterno-thyroid muscle.
26. The sterno-hyoid muscle.
27. The supra-clavicular lymphatic glands.
28. The clavicular attachment of the sterno-mastoid muscle.
29. The sternal attachment of the sterno-mastoid muscle.
30. The clavicular portion of the pectoralis major muscle.
31. The sternal portion of the pectoralis major muscle.
32. The triceps muscle.
33. The serratus magnus muscle.
34. The biceps muscle.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diately behind the superior turbinated bone in the upper wall. The *middle meatus* is larger than the superior, is situated between the middle and inferior turbinated bones, and extends along the posterior two-thirds of the outer wall of the nasal fossa. At its anterior part a long narrow passage, the *infundibulum*, leads upward into the anterior ethmoidal cells and thence to the frontal sinus. About the centre of the outer wall is the orifice, of variable size, which leads into the sinus of the superior maxillary bone, the *antrum of Highmore*. The *inferior meatus* is the space between the inferior turbinated bone and the floor of the nasal fossa, extending the entire length of the outer wall of the nose.

The lachrymal canal, or nasal duct, which conveys the tears from the lachrymal sac to the nose, opens into the anterior part of the inferior meatus. The lachrymal sac occupies the groove formed by the lachrymal bone and the nasal process of the superior maxillary bone (page 86). The *nasal duct* is twelve millimetres, or about half an inch, in length, and is directed downward, backward, and a little outward. Its opening in the inferior meatus in life is guarded by a valvular fold of the mucous lining, the *valve of Hasner*, and its position is two and one-half centimetres, or about one inch, behind the opening of the nostril, and one and three-fourths centimetres, or three-fourths of an inch, above the floor of the nose. The pharyngeal opening of the Eustachian tube is behind the inferior turbinated bone (Plate 12, No. 32). There is a great difference between the form and dimensions and character of the various openings of the nasal fossæ as they exist in the dried skull and as they present themselves in the recent state. This is chiefly dependent upon the arrangement of the *Schneiderian* or *pituitary membrane*, the vascular mucous membrane which lines the nasal cavities and the passages connected with them. This membrane is continuous with the skin at the inner borders of the anterior nares, with the mucous membrane of the pharynx through the posterior nares, and with the conjunctiva through the nasal duct and the lachrymal canaliculi, and is prolonged into the various sinuses communicating with the nasal fossæ already described. A coryza, or inflammation of the nasal mucous membrane, may thus implicate any of these structures, and a "cold in the head" or an attack of "hay fever" furnishes a demonstration of these

relationships. The mucous membrane varies much in thickness, vascularity, and appearance in these different parts. It is thickest and most vascular over the turbinated bones, where it forms projections especially in relation to the front and back part of the inferior turbinated bone, and thus encroaches upon the dimensions of the space of the nasal cavity. It is also quite thick on the septum, but in the intervals between the turbinated bones and on the floor of the fossæ it is thinner. The lining membrane within the cells and sinuses is very thin and pale, and very different from the proper lining of the nose. In the middle meatus the opening of the infundibulum is nearly closed by a fold of the membrane, and the opening into the antrum of Highmore is greatly diminished from its size in the dried bone, appearing usually as a round hole, about the centre of the middle meatus, and nearly two and one-half centimetres, or an inch, above the floor of the nose. The mucous lining of the nasal cavities is peculiarly modified in the nostrils, in the air-passages, and in the olfactory region. In the nostrils it is furnished with papillæ, a few hairs, and a squamous epithelial lining; in the air-passages the epithelium is columnar and ciliated; but upon the upper portion of the septum and upon the superior and middle turbinated bones, where the olfactory nerves are distributed, the epithelium is entirely columnar. These columnar cells terminate in fine processes, between which the microscope reveals nucleated fusiform cells, the so-called *olfactory cells.*

The *anterior nares* are the oval openings of the nasal cavities on the face, and are placed horizontally, so that in order to examine the septum and inferior turbinated bones the head should be thrown back (Plate 53, Fig. 1). A finger can be readily introduced into the nostril and passed far enough back to reach another finger introduced into the posterior nares through the mouth. The posterior nares are about the same height as the anterior (three centimetres, or one and a quarter inches), and measure transversely in the dried state twelve millimetres, or about half an inch, but in life the mucous lining considerably diminishes them. The ordinary deviation of the septum may block one nostril more or less, and interfere with the clearness of the voice, especially in singing. The floors of the nasal cavities are generally wider at the centre, where the passages are also

higher than elsewhere, and foreign bodies often become lodged here. The introduction of forceps to remove the latter, or for the extraction of nasal polypi, should be along the floor of the inferior meatus, and they should be opened so as to grasp the object vertically.

The *posterior nares* when the mouth is opened are usually blocked by the folds of the soft palate being drawn upward, and are thus cut off from the pharynx. Owing to this disposition, the "*nasal douche*" can be used so that the fluid introduced into one nostril shall pass over the soft palate and return by the other nostril.

The vascularity of the mucous membrane of the nose is due to the numerous capillaries which anastomose freely beneath its surface. The arteries of the nasal cavities are the anterior and posterior ethmoidal branches of the ophthalmic arteries, which supply the roof of the nose, the ethmoidal cells, and the frontal sinuses; the nasal arteries, from the internal maxillary, which supply the septum, the meatuses, and the turbinated bones; and the posterior dental arteries, from the internal maxillary arteries, which supply the antra. The veins of the interior of the nose terminate in the ethmoidal veins, which enter the ophthalmic vein. In children there is almost always a communication between the nasal veins and the superior longitudinal sinus through the foramen cæcum. This is usually closed about puberty, but may continue in the adult and perhaps explain persistent hemorrhage or the spread of inflammation from the nasal cavities to the meninges of the brain. There is a venous plexus (*rete nasi*) about the inferior turbinated bone which resembles a kind of cavernous tissue, very prone to bleed. Bleeding from the nose—or *epistaxis*—is generally due to some interference with the venous circulation. There are also venous communications with the frontal vein, and through the spheno-palatine foramen with the zygomatic plexus. The mucous membrane of the nose is abundantly furnished with sensory nerves. The *roof* is supplied by the nasal branches from the ophthalmic and filaments from the Vidian nerves; the *septum*, by branches from the nasal nerves, the spheno-palatine (or Meckel's) ganglions (Plate 3, Fig. 2, No. 6), and the naso-palatine nerves; the *floor*, by branches from the naso-palatine and anterior palatine nerves; and the *outer walls*, by filaments from the spheno-palatine

ganglions, and branches from the nasal, anterior dental, and anterior palatine nerves. The *olfactory nerves*, about twenty on each side, are derived from the olfactory bulbs, and pass through the foramina in the cribriform plate of the ethmoid bone. They are arranged in three sets on each side, and each nerve is invested with a fibrous prolongation from the dura mater. The *inner* set supply the upper part of the septum; the *middle* are the smallest, and are spread over the roof of the nose; the *outer* are the largest, and are divided into two groups, the anterior group supplying the mucous membrane over the superior turbinated bone, and the posterior group being distributed over the os planum and the middle turbinated bone. It will be noticed that the olfactory nerves are situated high up in the nasal cavities, and hence in the effort to smell intently the nostrils are always dilated. The partial loss of smell in some cases of facial paralysis has been ascribed to inability to dilate the nostrils. The olfactory nerves ramify between the mucous membrane and the bone, communicating freely with one another, and forming plexuses with elongated meshes. The fibres of these nerves are non-medullated, with a sparsely nucleated neurilemma. Interspersed between the columnar epithelial cells in the olfactory region there are peculiar cells having a nucleated body with two processes. These are called the *olfactory cells*, because one of the cell processes terminates on the surface of the mucous membrane and the other is believed to be in connection with the terminal filaments of the olfactory nerves.

THE REGION OF THE FACE.

The landmarks of the face (Plates 1 and 28) include, besides the bony prominences of the orbits (page 79) and the nose (page 108), the malar eminences and their backward prolongations into the zygomatic arches, which support the cheeks, and the angles, lower border, and mental eminence of the inferior maxillary bone, the latter giving prominence and character to the chin.

The skin of the face is generally very fine and thin, and adherent to the parts beneath, except over the eyelids, where it is peculiarly delicate and the subcutaneous cellular tissue is very loose. In relation to the alæ of

the nose and the chin it is more dense, and somewhat resembles the tissues of the scalp; and over the bony prominences contused wounds are often attended with a linear rupture of the skin similar to an incised wound. The lax arrangement of the cellular tissue elsewhere about the face is demonstrated in the swellings which follow inflammatory infiltration about the cheeks and mouth. There is much fat in the subcutaneous tissue of the face, especially in the anterior parts of the cheeks (Plates 18 and 19) and in relation to the zygomatic muscles. In children there is an aggregation of fatty lobules surrounded by a capsule over the buccinator muscles, called the "sucking cushions," because they are thought to be instrumental in distributing the atmospheric pressure and preventing the buccinator muscles from being pressed inward between the alveolar arches when a vacuum is created in the mouth. The skin of the face is intimately associated with many of the subjacent muscles, the habitual use of some of which produces the facial furrows and markings characteristic of certain expressions. A careful study of these lines and their varying modifications will prove of great value to the physician in forming a diagnosis of many diseases, especially in young children and the ignorant, in whom the facial expression is often the sole guide in the recognition of subjective symptoms. The only way of obtaining information from an infant who cannot communicate ideas or describe sensations by speech, is by noticing the expression and gestures. Such observation teaches that contraction of the brows indicates pain in the head; sharpening of the nostrils, pain in the chest; and drawing of the upper lip, pain in the abdominal region. There are certain lines (Jadelot's) which become marked in the face of any one suffering from serious diseases. Of these, the line which begins at the inner corner of the eye and passes outward toward the cheek-bone beneath the lower lid—the *oculo-zygomatic line*—is associated with disorder of the cerebro-nervous system. The line which extends from the wing of the nose round the corner of the mouth,—the *nasal line*,—if connected with marked dimpling of the cheek, points to disorder of the digestive tract. This is especially the case in infancy. The line which passes from the angle of the mouth to the lower part of the face—the *labial line*—is a sign of disease of the respiratory organs.

PLATE 17.

The skin removed on the left side of the neck to show the platysma myoides muscle and the usual position of the great external jugular vein.

1. The anterior temporal artery, seen through the scalp.
2. The position of the temporal artery, where it emerges from the parotid gland.
3. The position of the parotid gland.
4. The position of the submaxillary gland.
5. The external jugular vein, showing its course from the angle of the lower jaw to the middle of the clavicle.
6. The prominence of the thyroid cartilage (pomum Adami).
7. The platysma myoides muscle.
8. Superficial veins over the supra-clavicular fossa.
9. The helix.
10. The fossa (ovalis) of the anti-helix.
11. The fossa (scaphoidea) of the helix.
12. The anti-helix.
13. The tragus.
14. The concha.
15. The anti-tragus.
16. The lobule.

Dissected, Photographed and Colored from Nature by GEORGE MC CLELLAN, M.D.

Armstrong & Co. Lith. Boston

The muscles of the face, especially those called from their action the *muscles of expression,* are of finer texture and paler color than the muscles generally in other parts of the body. The muscles of expression also have no proper tendons of origin or insertion, are destitute of aponeuroses or sheaths, and blend with adjacent muscles by the most complex and delicate interlacement of their fibres (Plate 15), so that they do not present the same arrangement in every individual. They often vary in development even on the two sides of the face, thereby influencing the character and degree of the expressions. The muscles of the forehead, orbits, and nose are described with the anatomy of those regions. The muscles which surround the mouth and are attached to its upper and lower borders are remarkable for their interdependence (Plate 15) and for their great mobility. The *orbicularis oris muscle* is, like other sphincter muscles, composed principally of circular fibres, and has very slight attachments to the neighboring bones. The variety in the prominence of the lips in different individuals depends upon the size and thickness of this muscle. It consists of two portions, each possessing very marked differences from the other in the appearance and arrangement of its fibres. The *labial* portion is composed of very thin pale fibres which surround the mouth and have no bony attachment; the *facial* portion is broader, its fibres at the outer borders of the upper and lower lips intermingling with the fibres of other muscles, which converge toward it from the surrounding parts of the face. It is connected on each side to the bone by two fasciculi in the upper lip, one to the septum nasi and the other to the alveolar border in relation to the incisor teeth, and by a single fasciculus on each side in the lower lip to the lower jaw in relation to the canine tooth. There are tiny slips extending one on each side from the orbicularis to the anterior part of the nasal septum, producing the delicate furrow, called the *philtrum,* from the nose to the upper lip. This muscle counteracts all the other muscles which move the lips, the infinite play and variety of expression about the mouth depending upon the counterbalancing of their opposing actions. The ordinary action of the orbicularis closes the lips, and, on account of the outer surface of the muscle being intimately connected

with the lips and the overlying skin, its forcible contraction produces radiating wrinkles about the mouth in the skin of elderly persons.

The *levatores labii superioris et alarum nasi muscles* arise from the nasal processes of the superior maxillary bones near the inner borders of the orbits, and, passing downward, divide into *inner* slips, which are inserted into the alar cartilages of the nose, and *outer* slips, which blend with the orbicularis oris and the adjacent levatores labii superioris muscles in the upper lip. These muscles serve to dilate the nostrils and to draw upward the upper lip and the wings of the nose, and produce the changes in the countenance in the expressions of indignation, disgust, and derision. Their habitual use occasions the furrows which extend from the side of the nose to the corners of the mouth. The *levatores labii superioris* (*proprius*) *muscles* arise from the lower borders of the orbits beneath the orbicular muscles of the eyelids, *above* the infra-orbital foramina, and, overlapping the deep origins of the compressor nasi and levator anguli oris muscles, on each side, their fibres blend with the orbicularis oris. The two *levator anguli oris muscles* arise underneath the preceding muscles from the canine fossæ of the superior maxillæ *below* the infra-orbital foramina, and blend at the angles of the mouth with the contiguous muscles. The *zygomaticus muscle* arises on each side from the malar bone near its junction with the zygoma, and passes obliquely in a bed of fatty tissue across the side of the face to the angle of the mouth, where its fibres interlace with those of the other muscles of the upper lip. The action of this muscle is seen in laughing and snarling. Sometimes an additional muscular slip passes downward from the orbicularis palpebrarum, and, taking a course parallel to the zygomaticus, is called the *zygomaticus minor.* The *depressor anguli oris muscle* on each side has a broad origin from the oblique line of the inferior maxilla behind the mental foramen, and its fibres converge upward to a narrow insertion at the angle of the mouth, where they intermingle with those of the zygomaticus, the orbicularis oris, and the upper portion of the platysma muscle, known as the *musculus risorius* (or laughing muscle of Santorini), and also with the under strata of the levator anguli oris. The peculiar arrangement of the interlacing of the fibres of this muscle at the corner of the mouth with so many others

renders this part the most mobile in the face. The depressor anguli oris is the most expressive of all the facial muscles: it plays an important *rôle* in melancholy and sorrowful emotions.

The *depressores labii inferioris muscles* arise from the lower jaw, between the symphysis and the mental foramina, a quantity of fat being generally interspersed among their fibres, which are inserted into the lower lip, blending with one another and the outer portion of the orbicularis. These muscles draw the lower lip downward and a little outward, as in the expression of irony or sarcasm.

The *levatores menti muscles* arise in conical bundles from the incisor fossæ of the lower jaw, and are inserted into the skin of the lower part of the chin. Their action is to wrinkle the chin, as in doubt, and to raise the chin and protrude the lower lip. The latter action is made use of in shaving the chin.

The two *risorius muscles* are constituted by a separation of the upper fibres of the platysma myoides muscles, which are inserted into the superficial layer of fibres from the depressor anguli oris and the orbicularis muscles at the angles of the mouth. A few fibres of the risorius muscles occasionally arise from the fascia over the masseter muscles. When these are pronounced, the action of these muscles is noticeable in laughter, but as they usually exist they produce the smile of scorn or derision rather than that of good humor. There is often great diversity in the development of these muscles on the two sides of the same face. Beneath the risorius and other muscles which blend at the angles of the mouth are the oral attachments of the *buccinator muscles.* These muscles are chiefly concerned with keeping the food between the teeth during mastication, and therefore are more properly classified with the regions of the cavity of the mouth (page 172) and of the pharynx. They arise from the molar portions of the alveolar processes of the upper and lower jaws, and posteriorly from the fibrous intersections which separate them from the superior constrictor muscles of the pharynx on each side. These fibrous bands extend from the hamular processes of the internal pterygoid plates to the posterior extremities of the mylo-hyoid ridge on each side of the lower jaw, near the last molar teeth. They are called the *pterygo-*

maxillary ligaments. The fibres of the buccinator muscles pass forward, to be inserted in a peculiar manner at the under surface of the other muscular structures at the angles of the mouth. The upper fibres join the upper lips, and the lower fibres the lower lips, while the central fibres cross one another. Unlike the rest of the facial muscles, the buccinators are covered with a sheath of fascia externally, which greatly increases their power. In relation to the masseter muscles a quantity of fat, on each side, fills up the zygomatic fossæ, giving to the face a fulness or roundness in these parts. Its absorption produces the sunken condition of the cheeks in emaciated individuals. The buccinator muscles widen the aperture of the mouth by pulling upon its corners, and their power for expelling the air from the mouth is seen in whistling, or in blowing a trumpet (whence their name).

The *masseter muscles* arise from the lower edges of the zygoma and malar bones. These muscles consist of superficial and deep strata of fibres arranged in a crossed manner which greatly augments their power. The *superficial* fibres constitute the principal part of each muscle, and take origin by a thick tendinous aponeurosis from the malar process of the superior maxilla and from the lower border of the anterior two-thirds of the zygoma (Plates 16, 18, and 21). These fibres pass obliquely backward, and are inserted into the angle and the lower half of the outer surface of the ramus of the jaw. The *deep* fibres are mainly muscular, and arise from the posterior third of the lower border and the whole of the inner surface of the zygomatic arch. They pass downward and forward, and are inserted into the upper half of the ramus and the outer surface of the coronoid process, blending with the insertion of the superficial fibres. The anterior border of the muscle is therefore formed of the two layers of fibres, and presents a thick prominence which can be readily felt by the finger inserted in the mouth between the cheek and the malar bone. The deep portion of this muscle is partly covered by the superficial portion anteriorly, and it is in relation to the parotid gland posteriorly. The masseter muscles assist largely in producing the contour of the lower part of the face. Their function is to raise the lower jaw and to assist the temporal muscles in mastication. There is a dense layer of fascia, derived

from the deep cervical fascia, which covers each masseter muscle, called the *masseteric fascia.* It adheres intimately to the tendon of origin of the superficial portion, and binds it firmly to the ramus of the jaw. A few strong fibres also connect the origin of the deeper portion with the tendon of the temporal muscle at the coronoid process. The *motor* nerves of the masseter muscle are, like those of the temporal (page 14), derived from the inferior maxillary nerve. The spot where reflex contraction of the masseter muscle may be produced by electrical stimulation is four centimetres, or about an inch and a half, in front of the ear, on a line drawn from the apex of the nose to the lobule (Plate 53, Fig. 1, No. 21).

The arteries of the face are very numerous, and are derived from the facial, internal maxillary, and temporal branches of the external carotid artery. The *facial* (or *external maxillary*) *artery,* after it has tunnelled through the submaxillary gland, appears at the side of the face, coursing over the body of the lower jaw, accompanied by the facial vein in front of the masseter muscle (Plate 18, No. 14, and Plate 19, No. 13). In this relation the artery is comparatively superficial, and its pulsation can be readily detected or checked by compression. In order to secure it with a ligature the incision should be made parallel to the anterior border of the masseter muscle, about three centimetres, or an inch and a quarter, in front of the angle of the jaw; but it should be remembered that the vessel usually lies in a loose bed of fat, and that the skin and platysma muscle over it are freely movable, so that it will readily slip aside. It may be rendered more tense by depressing the lower jaw. From the masseter muscle the artery passes very tortuously to the corner of the mouth, where it gives off ordinarily the inferior labial and coronary arteries to the lips, and is continued up along the side of the nose to the inner canthus of the eye, terminating as the angular artery (Plate 19, No. 4). In its course over the face it gives off branches to the masseter and buccinator muscles. The *inferior labial artery* passes under the depressor anguli oris and anastomoses with the mental, submental, and inferior coronary arteries. The *inferior coronary artery* is usually given off from the facial near the corner of the mouth, either by an independent trunk or in common with the superior coronary. It passes beneath the

depressor anguli oris, pierces the orbicularis, and, running between this muscle and the mucous membrane of the lip, inosculates with its fellow and the inferior labial and mental arteries. The *superior coronary* is larger and more tortuous than the inferior, and arises from the facial artery beneath the zygomaticus muscle. It also runs between the muscular structure of the upper lip and the mucous membrane, and, inosculating with its opposite fellow, forms with the two inferior coronary arteries a *vascular circle*, which can be felt pulsating on the inside of the mouth by compressing the lips anywhere near their free borders. The superior coronary supplies branches to the septum and ala of the nose. Sometimes this vessel arises independently from the transverse facial branch of the temporal artery (Plate 19, No. 9), which is then much enlarged and superficial.

The *lateral artery of the nose* is supplied by the facial to the ala and dorsum of the nose. It anastomoses with the nasal branch from the ophthalmic artery, the septal artery, the infra-orbital artery, and the communicating vessels from the other side of the nose.

The *angular artery* is the termination of the facial, and ascends among the fibres of the levator labii superioris et alæ nasi muscle to the inner angle of the orbit, where it inosculates with the nasal branch of the ophthalmic artery in relation to the tendo palpebrarum, on the nasal side of the lachrymal sac. The anastomoses of the facial artery are so numerous that ligature of both ends of a divided vessel in this region is often necessary. The great vascularity of the face occasions very rapid healing in wounds, which should have their edges accurately adjusted as soon as possible, to avoid distortion. The same cause also occasions the occurrence of nævi and erectile tumors about the face. The remarkable success of plastic surgery in this region is due to the great vitality of the flaps, and extensive injuries involving loss of substance are often repaired rapidly.

The *facial artery* and its branches are surrounded by a minute plexus of vaso-motor and dilator nerves, derived from the superior cervical ganglion of the sympathetic nerve (Plate 36, No. 49), to the influence of which is probably due the sudden blushing or pallor of the countenance which attends mental emotions, as in shame or fear.

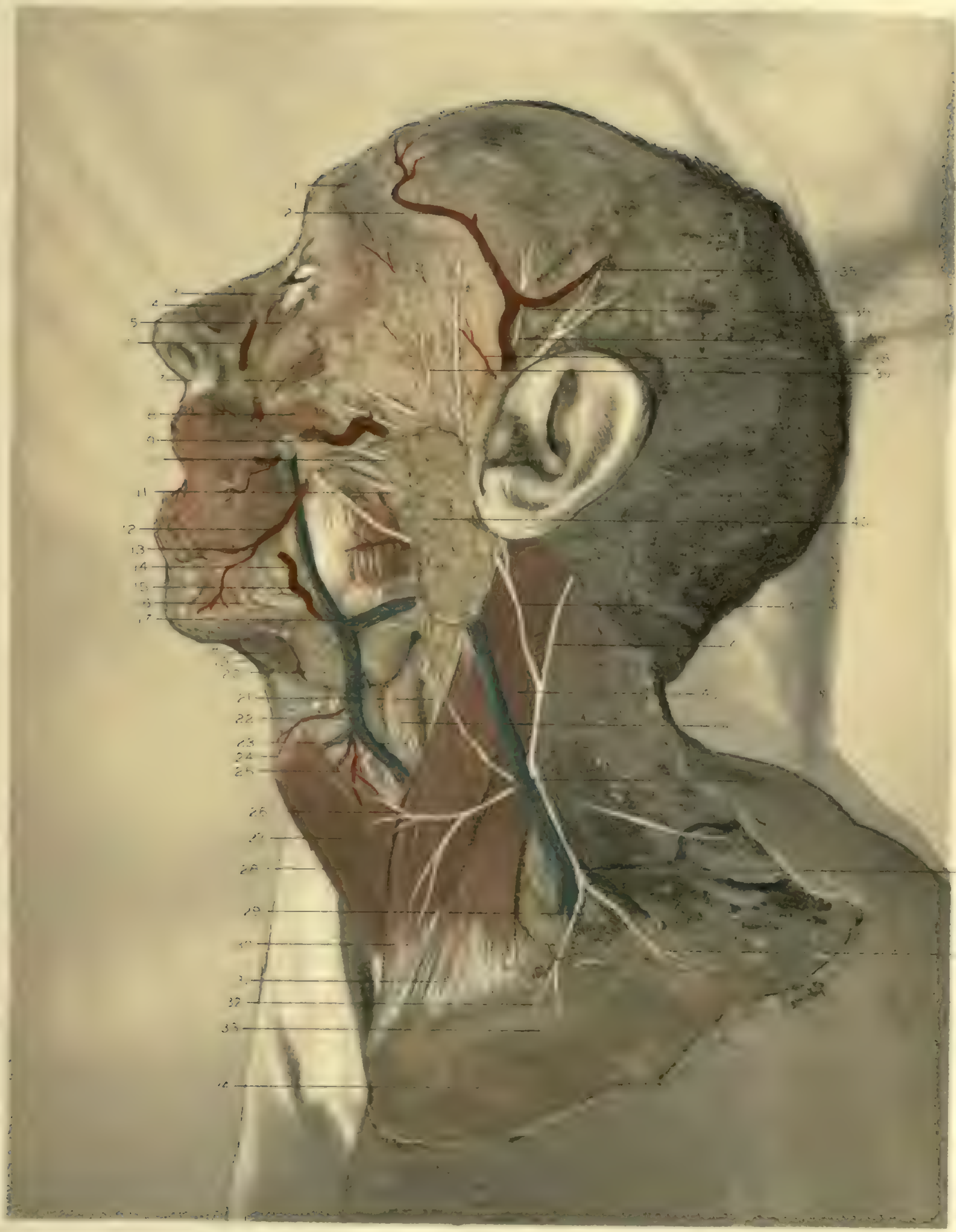
The *facial vein* begins at the inner corner of the eye, where it receives the blood from the frontal and supra-orbital veins, and is called the *angular vein* where it is in relation to the angular artery. Thence it passes down the side of the nose, with the lateral nasal artery, and from the alar cartilage it takes an oblique course to the anterior border of the masseter muscle, being interposed between it and the facial artery, with which it is apt to be ensheathed (Plate 18, No. 15, Plate 19, No. 13, and Plate 21, No. 32). It usually passes directly over the termination of the parotid duct (Plate 18, No. 10). The veins emptying into the facial vein are the tributary veins from the territories supplied by the branches of the facial artery; but at the corner of the mouth it is increased in size by the communicating veins from the infra-orbital and temporo-maxillary veins. By far the most important of the communications of the facial vein are the veins which bring it in relation with the *cavernous sinus* at the base of the brain. This connection is twofold. There is a direct communication with the angular vein through the ophthalmic vein (page 95), and an indirect communication through the *deep facial vein*, from the pterygoid plexus, which is in relation with the cavernous sinus by small veins through the foramen of Vesalius, in the sphenoid bone, and the fibrous tissue of the foramen lacerum medium. There are no valves in the facial vein, or at the junction of any of its branches, so that when it is involved in wounds the bleeding from it is very copious. It is also peculiar in remaining more patent after being cut than superficial veins elsewhere, which renders it liable to septic absorption. The facial vein terminates in the internal jugular vein near the bifurcation of the common carotid artery. The *lymphatic vessels of the face* converge chiefly toward the submaxillary ganglia, while some go to a few lymphatic ganglia which lie superficially over the parotid gland (Plate 16).

The sensory nerves of the face are mainly derived from the terminal branches of the fifth cranial, or trifacial, nerve (Plate 3, Fig. 2). An accurate knowledge of the position of the foramina through which they make their exits upon the face (Plate 28), and of their cutaneous areas of distribution (Plate 53, Fig. 1), is of the greatest value in determining the seat and treatment of neuralgic affections in this region. The oph-

PLATE 18.

The superficial fascia removed from the left side of the face, together with the platysma myoides muscle from the neck, to show the superficial vessels and nerves in these regions, and especially the superficial relations of the parotid gland.

1. The supra-orbital artery.
2. The anterior branch of the temporal artery.
3. The angular artery.
4. The compressor naris muscle.
5. The levator labii superioris muscle.
6. The lateral nasal artery and vein.
7. The levator anguli oris muscle.
8. The zygomaticus major muscle.
9. The transverse facial artery.
10. The duct of Stenson, from the parotid gland.
11. The infra-orbital branches of the facial nerve.
12. The orbicularis oris muscle.
13. The inferior labial artery (arising in this case from the transverse facial artery).
14. The facial artery.
15. The facial vein.
16. The depressor labii inferioris muscle.
17. The submaxillary vein, joining the facial vein with the external jugular vein.
18. The anterior belly of the digastric muscle.
19. The mylo-hyoid muscle.
20. The submaxillary gland.
21. The facial branch of the auricularis magnus nerve.
22. The oblique vein, joining the facial vein with the internal jugular vein.
23. The point of bifurcation of the common carotid artery.
24. The thyroid notch (pomum Adami).
25. Superficial branches of the superior thyroid artery.
26. The superficial transverse cervical nerves.
27. The left sterno-thyroid muscle.
28. The left sterno-hyoid muscle.
29. The fascia over the supra-clavicular fossa.
30. The sternal portion of the sterno-cleido-mastoid muscle.
31. The clavicular portion of the sterno-cleido-mastoid muscle.
32. The sternal and clavicular nerves, from the cervical plexus of nerves.
33. The fascia over the clavicle.
34. The fascia over the great pectoral muscle.
35. The superficial temporal nerves.
36. The auriculo-temporal nerve.
37. The temporal artery.
38. The orbital branch of the temporal artery.
39. The temporal branches of the facial nerve.
40. The parotid gland.
41. The auricular branch of the auricularis magnus nerve.
42. The mastoid branch of the auricularis magnus nerve.
43. The external jugular vein in its proper position.
44. The external and internal carotid arteries covered by their sheaths of the deep fascia.
45. The auricularis magnus nerve.
46. The junction of the superficial cervical veins with the external jugular vein.
47. The acromial nerve.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thalmic division of the trifacial nerve supplies the supra-orbital, the supra-trochlear, the lachrymal, the infra-trochlear, and the naso-lobular, all of which have been described with their special regions.

The *superior maxillary* division of the trifacial nerve terminates upon the face in the infra-orbital nerve and the temporo-malar nerve, the former of which emerges, with the infra-orbital artery, from the infra-orbital foramen under the levator labii superioris muscle. The *infra-orbital foramen* is six millimetres, or about a quarter of an inch, below the margin of the orbit, and directly in a straight line drawn from the supra-orbital foramen, which is three centimetres, or an inch and a quarter, from the external angular process, toward the root of the nose, to the mental foramen, which is the same distance outward from the symphysis of the lower jaw. The location of this foramen is of surgical importance, as the nerve is apt to be compressed within its bony canal. The foramen may be reached by a trap-door incision made parallel to the lower margin of the orbit, over the point just indicated. The infra-orbital canal, in which the nerve is lodged before it makes its exit at the foramen, presents considerable variations, so that the operation for resection of the nerve is better done by seeking the foramen first, and then chiselling away the bone so as to expose the nerve in the anterior part of its course. In close relation to the infra-orbital foramen is the plexus formed by the communications between the deep branches of the facial nerve, which supplies the adjacent muscles, and the descending branches of the infra-orbital nerve. Immediately after issuing from the foramen, the nerve separates into a leash of fibres, some of which, the *palpebral*, pass upward beneath the orbicularis palpebrarum muscle to supply the lower eyelid; others, the *nasal*, pass to the side of the nose; and others, the *labial*, and the most numerous, descend beneath the levator labii superioris muscle and terminate in the papillæ of the upper lip and the bordering mucous membrane of the mouth. The *temporo-malar nerve* arises from the superior maxillary nerve within the spheno-maxillary fossa, whence it enters the orbit and divides into temporal and malar branches. The *temporal branch* runs in a groove in the malar portion of the orbit and passes through a foramen in the malar bone. It ascends under the temporal muscle, which

it pierces, together with its fascia, about two and a half centimetres, or an inch, above the zygoma, and is distributed to the skin of the temple and side of the forehead (Plate 53, Fig. 1, No. 20). The *malar branch* issues on the face through a foramen in the malar bone, of variable size and position, and, piercing the outer fibres of the orbicularis palpebrarum muscle, supplies the skin of the cheek over the malar bone, being sometimes called the *subcutaneus malæ.*

The sensory portion of the inferior maxillary division of the trifacial nerve terminates upon the face in the *auriculo-temporal nerve*, the *buccal nerve*, and the *mental nerve.* The *auriculo-temporal nerve* arises by two roots, which surround the middle meningeal artery (Plate 3, Fig. 2, No. 20), and then combine to form a single trunk, which passes behind the external pterygoid muscle and the neck of the lower jaw. It first ascends beneath the parotid gland, and then passes, with the temporal artery and vein, over the root of the zygoma and divides into anterior and posterior branches (Plate 18, No. 36, and Plate 19, No. 20). The *anterior branch* supplies the skin over the vertex and the temporal region; the *posterior branch* supplies the upper part of the pinna and the adjacent integument. The auriculo-temporal nerve communicates, near its origin, with the otic ganglion. It sends auricular branches to the meatus externus and the membrana tympani (page 65), and to the tragus and auricle. It also sends branches to the temporo-maxillary joint and to the parotid gland. The *buccal nerve* arises usually in common with the anterior deep temporal nerve, and passes either above or between the fibres of the external pterygoid and temporal muscles to reach the buccinator muscle, where its filaments spread out and form with the buccal branches of the facial nerve a plexus in relation to the facial vein. The buccal nerve supplies sensation to the skin, the mucous membrane, and the buccal glands of the cheek. This is borne out by several instances where this nerve has been found to originate from the superior maxillary nerve. The facial nerve incites the motor power of the buccinator muscle by a special branch (page 130). The *mental nerve* is the termination of the inferior dental branch of the inferior maxillary nerve, which emerges, with the mental artery, at the mental foramen in the lower jaw, beneath the

depressor anguli oris muscle. It divides into a leash of fibres, some of which supply the integument over the chin, and the rest are distributed to the papillæ and mucous membrane of the lower lip. The skin covering the parotid gland and contiguous part of the cheek is supplied with sensation by the great auricular branch of the cervical plexus of nerves (Plate 53, Fig. 1, No. 27).

The motor nerves of the face are derived from the branches of the seventh cranial or facial nerve, which emerge at the anterior border of the parotid gland over the masseter muscle. The origin of the facial nerve, from the lateral tract of the medulla oblongata (page 41), and its course through the aqueduct of Fallopius in the temporal bone (page 69) to its exit from the skull at the stylo-mastoid foramen, have been described. After issuing from the foramen the facial nerve sends off motor branches to the posterior auricular, occipital, digastric, and stylo-hyoid muscles, and then, in relation to the ramus of the lower jaw, divides into two primary facial branches, named, from their distribution, the *temporo-facial* and *cervico-facial nerves*, which form, by their communications within the substance of the parotid gland, the plexus called by the old anatomists the *pes anserinus* (Plate 19, No. 23), from its fancied resemblance to the outspread skeleton of a goose's foot.

The *temporo-facial nerve* is the largest, and in passing through the parotid gland it crosses the external carotid artery and the neck of the jaw. It is joined by several sensory twigs from the auriculo-temporal branch of the trifacial nerve, and divides into temporal, malar, and infra-orbital branches. The *motor temporal nerves* ascend over the zygoma and supply the muscles about the orbit and eyelids, and form sensory connections with the supra-orbital nerve, with the temporal branch of the superior maxillary nerve, and with the auriculo-temporal and lachrymal nerves. The spot where reflex contraction of the temporal muscle may be produced is two and a half centimetres, or about an inch, in front of the ear, on a line drawn from the eyebrow to the top of the auricle (Plate 53, Fig. 1, No. 6). The *motor malar nerves* cross the malar bone to the outer angle of the orbit, supplying the contiguous portion of the orbicularis muscle, and join with sensory filaments from the lachrymal, supra-orbital, and subcutaneus malæ

nerves. The motor infra-orbital nerves are comparatively of larger size, and consist of superficial and deep branches which pass forward over the masseter muscle to be distributed to the muscles beneath the lower margin of the orbit and about the mouth. The *superficial branches* supply the superficial muscles of the face and form sensory connections with the nasal and infra-trochlear nerves along the nose. The *deep branches* pass beneath the zygomaticus and levator labii superioris muscles, which they supply, and establish sensory connections with the infra-orbital branches of the superior maxillary nerve, forming the *infra-orbital plexus,* already mentioned. The *cervico-facial nerve* is joined within the parotid gland by sensory filaments from the auricularis magnus branch of the cervical plexus of nerves. It descends toward the angle of the jaw, and divides into the buccal, supra-maxillary, and infra-maxillary nerves. The *motor buccal nerves* pass over the masseter muscle to supply the buccinator and orbicularis oris muscles. They join with filaments of the infra-orbital motor nerves, and form sensory connections with the buccal branch of the inferior maxillary nerve. The *supra-maxillary nerves* pass beneath the platysma and depressor anguli oris muscles, which they supply. They establish sensory communications with the mental branch of the inferior maxillary nerve. The *infra-maxillary nerves* consist of several arching branches beneath the platysma muscle, which they supply, between the jaw and the hyoid bone. One of these branches is joined by the superficial cervical nerve from the cervical plexus (Plate 19, No. 27).

THE REGION OF THE PAROTID GLAND.

The parotid gland, so called because it is near the ear (Plates 13 and 18), is the largest of the salivary glands. It weighs from half an ounce to an ounce in different individuals, and is lodged in a pyramidal bed upon the side of the face, below and in front of the ear. Its external surface is firmly bound down by an extension of the fascia from the masseter muscle, which is here called the *parotid fascia,* and which serves to conceal the form of the gland from external view. The tough and unyielding nature of this fascia accounts for the intense pain often experienced in cases

of abscesses involving the gland, or in *parotitis* (mumps), from pressure upon the sensory nerves within the gland. From the inner layer of the parotid fascia prolongations extend into the substance of the gland, which partition off and support the lobules, the gland being of the compound racemose variety. The lobules consist of aggregations of small cæcal dilatations (the *alveoli*) of fine canals, which are lined with a layer of epithelial cells, and supported by the connective tissue which is continued inward from the surface of the gland, as above mentioned. The peri-lobular tissue contains lymph-spaces, which are in relation to the capillary vessels and ultimate nerve filaments which preside over the nourishment and secretory functions of the glandular structure. The canals are the excretory ducts of the lobules, which empty into the main duct of the gland, called the *duct of Stenson*, which leaves the gland at its anterior border on the masseter muscle. Stenson's duct is a firm white tube, the size of a goose-quill, and takes a parallel course to the zygoma in close relation to the transverse facial artery, on a line drawn from the external auditory meatus to a point midway between the ala of the nose and the angle of the mouth (Plate 18, No. 10). About the middle of this line the duct, after passing over the facial vein, turns abruptly inward around the anterior border of the masseter muscle and penetrates the buccal fat and the buccinator muscle, to open upon the mucous membrane of the mouth, opposite the second molar tooth of the upper jaw, by a narrow orifice. The saliva secreted by the parotid gland is an alkaline, watery fluid, which aids in the mechanical disintegration of the food and also possesses the property of converting starch into dextrin and grape sugar.

The space which the gland occupies is bounded above by the zygoma, below by the sterno-mastoid and digastric muscles, behind by the external auditory meatus and the mastoid process of the temporal bone. The gland is prolonged anteriorly over the ramus of the jaw and masseter muscle to a variable extent. It is often continuous with the structure of the sub-maxillary gland, but is usually separated from it by a fold of the deep cervical fascia, called the *stylo-maxillary ligament.* There is also an extension of the deep cervical fascia which is connected with the sheaths of the pterygoid muscles and the pterygoid process of the sphenoid bone.

PLATE 19.

The parotid gland removed from the left side of the face to show the branches of the facial nerve, and the fascia removed from the posterior cervical triangle to show more clearly the superficial cervical plexus of nerves.

1. The frontal muscle and branches of the frontal artery and supra-trochlear nerve.
2. The supra-orbital artery and nerve.
3. The anterior branch of the temporal artery.
4. The angular artery.
5. The compressor naris muscle.
6. The lateral nasal artery and vein.
7. The levator anguli oris muscle.
8. The zygomaticus major muscle.
9. The transverse facial artery.
10. The masseter muscle.
11. The superior coronary artery.
12. The inferior coronary artery.
13. The facial artery and vein.
14. The depressor anguli oris muscle.
15. The carotid artery covered by its sheath.
16. The transverse cervical nerve, passing beneath the external jugular vein.
17. The sterno-hyoid muscle.
18. The interspace between the sternal and clavicular portions of the sterno-mastoid muscle.
19. The posterior branch of the temporal artery.
20. The auriculo-temporal nerve.
21. The temporal branches of the facial nerve.
22. The temporal artery.
23. The remains of the parotid gland, dissected away to show the relations of the facial nerve, and the *pes anserinus.*
24. The vessels and nerves to the buccinator muscle.
25. The splenius capitis muscle.
26. The auricularis magnus nerve.
27. The cervical branch of the facial nerve.
28. The occipital artery.
29. The trapezius muscle.
30. The occipitalis minor nerve.
31. The spinal accessory nerve.
32. The descending cervical nerves (sternal, clavicular, and acromial branches).
33. The scalenus medius muscle.
34. The external jugular vein.
35. The supra-clavicular fossa, occupied with fat and superficial veins.

N. B.—The transverse facial artery in this instance supplies the coronary arteries which usually arise from the facial artery proper.


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The gland is therefore in a measure enclosed in a fascial envelope. This is normally very thin over the deeper parts, but when the gland is affected with any chronic morbid enlargement it is thickened, and may be then more properly regarded as a sac. There is, furthermore, a peculiar invagination of the deep cervical fascia between the anterior surface of the styloid process and the posterior border of the external pterygoid muscle, which reaches to the wall of the pharynx, so that in post-pharyngeal abscess there is often an external swelling in the parotid region. In several cases in the author's experience, where the pharyngeal abscess was so large that it was feared the evacuation of the pus through direct incision by the mouth might lead to suffocation by its entering the glottis, external drainage was established by careful dissection down to the stylo-maxillary ligament and tapping the space above referred to just below the lower border of the parotid gland.

The dimensions of the space occupied by the gland vary with the movements of the lower jaw, and with the changes in its angle peculiar to infancy and to old age. In the two latter instances it is naturally increased at its lower part, owing to the obliquity of the angle, and it is also increased when the head is extended and the jaw moved forward. When the head is flexed it is diminished.

The relations of the parotid gland are of the greatest importance from a surgical point of view, as its removal, when diseased, is one of the most difficult and hazardous of surgical undertakings. The skin and superficial fascia over this region are loose and movable, and contain some fibres of the platysma muscle in the lower part. In the connective tissue between the superficial fascia and the deep or parotid fascia there are a few branches of the superficial cervical plexus of nerves, and several lymphatic glands, which receive the lymphatic vessels from the neighboring portion of the scalp and the superficial tissues of the face (Plate 16). These are the *extra-parotid lymphatic glands*, the enlargement of which by disease constitutes a form of false parotid tumor. There is another species of lymphatic tumor in this region which is very difficult to distinguish from enlargement of the gland itself, owing to the involvement of the *intra-parotid lymphatic glands.* These are usually two or three in number, though sometimes

only one, and receive the lymph from the deep temporal and maxillary structures accompanying the vessels into the interlobular spaces within the gland.

The deep surface of the parotid gland is very irregular, consisting of projections of its substance which fit into the spaces between the subjacent parts. These projections, which extend from the main body of the gland, are known respectively as the *glenoid lobe*, which is received into the portion of the glenoid fossa of the temporal bone not occupied by the condyle of the lower jaw, and limited anteriorly by the Glaserian fissure and posteriorly by the vaginal process; the *pterygoid lobe*, which projects behind the ramus of the jaw, between the two pterygoid muscles and internal to the internal maxillary artery; the *carotid lobe*, which is in relation to the base of the styloid process, and interposed between the external carotid artery and the internal carotid artery and internal jugular vein; and the *masseteric lobe*, or *socia parotidis*, which is of variable size, and lies upon the masseter muscle, usually *above* Stenson's duct, into which it opens by a separate duct.

The external carotid artery, at the angle of the jaw, gives off the *posterior auricular artery* and continues upward under the parotid gland for about two-thirds of its extent, and opposite the neck of the jaw it enters the gland, and, tunnelling through its substance, emerges at the upper border, where it is called the *temporal artery*. Just before quitting the gland the external carotid gives off the *internal maxillary artery*, which passes behind the ramus of the jaw; while the temporal artery in immediate relation with the upper border of the gland sends off the *transverse facial branch* (Plate 18, No. 9). The lower part of the internal surface of the gland is separated from the external carotid artery by the confluence of the temporal and internal maxillary and posterior auricular veins, which empty into the external jugular vein at its commencement in the neighborhood of the angle of the jaw. The upper part of the gland, through which the external carotid artery passes, is in immediate relation with the internal carotid artery and the internal jugular vein (Plate 22, Fig. 2), and interior to these vessels are the pneumogastric, spinal accessory, hypoglossal, and glosso-pharyngeal nerves (Plate 36). The facial nerve

enters the parotid gland at its posterior border, on a line with the entrance of the external carotid artery, and divides into the temporo-facial and cervico-facial nerves, which, branching between the lobules of the gland, form the *pes anserinus,* and emerge at the superior and anterior borders, to be distributed to the region of the face (page 129). The auriculo-temporal branch of the inferior maxillary nerve penetrates the gland behind the neck of the jaw, and the auriculo-parotidian branch of the auricularis magnus nerve, from the cervical plexus, enters it near the lobule of the ear (Plate 19, No. 20). Both of these nerves supply sensation and form connections with the facial nerve within the substance of the gland; and in rapidly-growing tumors of the gland, not only is facial paralysis apt to occur from pressure on the facial nerve, but the pain is often referred to the parts supplied by the auriculo-temporal nerve, viz.,—the pinna, the temple, the meatus, and the temporo-maxillary joint.

From the above description it will be understood that it is the upper part of the gland which extends most deeply toward the base of the skull and involves structures of vital importance.

In some dissections the inward projections of the gland have been found to reach such a depth, and their adhesions to be so general to hard and soft structures alike, that an enucleation or extirpation of the entire glandular mass would seem to be a well-nigh impossible task; but it has not proved such in the hands of some bold enough to undertake it, and their success has been due to the most exact knowledge of this complex region, alike in its normal condition and in the possible changes which disease may occasion in the parts, a precision of knowledge which is probably required by no other operation in surgery. The tendency of most morbid growths of the gland is outward, in spite of the resistance of the parotid fascia, and the deep portion, although the fascia over it may be thickened by inflammation, is apparently drawn forward. This statement is based upon the author's clinical observation, and the opportunity afforded him of examining a scirrhous parotid on the dissecting-table. The cavity of the wound after complete extirpation of the parotid was found to be larger at the bottom than at the surface. The styloid process, quite uncovered by the removal of the little muscles which are attached to it, projected

into the back part of the cavity; and the internal carotid artery and internal jugular vein, with the hypoglossal, glosso-pharyngeal, and pneumogastric nerves, were at the bottom of the wound, covered by a thin layer of fascia.

THE DEEP STRUCTURES OF THE FACE.

The deep structures of the face, included in the pterygo-maxillary and superior maxillary regions, are of great surgical interest, owing to the importance of their relations and connections. The external landmarks of the *pterygo-maxillary region* (Plates 1 and 28) are the prominences of the zygoma and lower jaw. Within the mouth the finger can detect, through the mucous membrane, the contour of the ramus of the jaw and its coronoid process and their relations to the external pterygoid plate of the sphenoid bone. The zygoma is subcutaneous, and its prominence depends upon the development of the malar bone, the buttress of the cheek. The attachment of the superficial and deep fibres of the masseter muscle to the under and inner surface of the zygomatic arch have been described (page 122), as have also the relations of the transverse facial artery, the duct of Stenson, and the branches of the facial nerve, which radiate from the anterior border of the parotid gland (page 131). Under these parts, surrounded by some loose fat, is the coronoid process of the lower jaw, with the insertion of the temporal muscle (page 14). The *sigmoid notch* separates the coronoid process from the condyle of the jaw, which articulates with the anterior portion of the glenoid cavity of the temporal bone, forming the *temporo-maxillary joint.* This is an arthrodial joint, and is provided with an *inter-articular fibro-cartilage,* which is of oval form and thicker at its margin than at its centre. Between the fibro-cartilage and the glenoid cavity there is a pouch of synovial membrane, and interposed between the fibro-cartilage and the condyle of the jaw is another, smaller pouch of synovial membrane. Sometimes these pouches are connected through a deficiency in the centre of the fibro-cartilage. The fibro-cartilage serves as a buffer to prevent shock in the violent closing of the jaws and thus ward off injury to the brain through the thin bony plate of the glenoid cavity.

There are two lateral ligaments,—a short, *external ligament*, extending from the tubercle of the zygoma to the outer and posterior borders of the neck of the jaw, and a long, flat, *internal ligament*, which extends from the spinous process of the sphenoid bone to the inner border of the dental foramen on the inside of the ramus of the jaw. This ligament is more properly a layer of fascia which protects the internal maxillary vessels and the auriculo-temporal nerve from pressure by the contraction of the pterygoid muscles in the movements of the lower jaw.

The so-called *capsular ligament* consists of a few fibres which arise from the margin of the glenoid cavity and blend below with the lateral ligaments, mainly at their posterior parts. The nerves to this joint are derived from the auriculo-temporal, which is in close connection with the neck of the capsule and the masseteric branch of the inferior maxillary nerves.

The form of this articulation admits of motion from side to side, as well as upward, downward, forward, and backward, so as to enable the teeth thoroughly to triturate the food. The lower jaw is *elevated* mainly by the temporal and masseter muscles, with the assistance of the internal pterygoid muscle. The fibro-cartilage holds its proper relation to the condyle in all the ordinary movements of the jaw, but if depression is carried to too great an extent, as in the act of yawning, forward dislocation of the jaw may occur. The articular eminence at the under part of the zygoma is coated with cartilage, is in contact with the fibro-cartilage of the joint in front, and ordinarily the condyle never reaches the top of the eminence, although it glides forward when the mouth is widely opened. If, however, the depression of the lower jaw is strained in this position, the external pterygoid muscle contracts forcibly and draws the condyle over the eminence into the zygomatic fossa, leaving the fibro-cartilage behind. The condyle at once becomes more or less fixed in its new position by the action of the elevator muscles. A proper understanding of the mechanism of this displacement is necessary for its reduction, which demands that the lower jaw should be drawn forward, forcibly depressed, and then pushed backward and upward. The posterior surface of the neck and the upper portion of the ramus of the lower jaw are embraced by the parotid gland, the pterygoid and carotid lobes of

which are projected inward toward the base of the skull (page 134). The connections of the deep parts beneath the inferior maxillary articulation are so intimate that they offer great difficulty to the dissector bent upon investigating the diverse branches of the internal maxillary artery and their relations to the complex nerves which traverse this region. These can be properly displayed only after removal of the zygoma and the ramus of the jaw (Plate 22, Fig. 2); but before this is done the attachments of the pterygoid muscles should be understood.

The *external pterygoid muscle* has a double origin, the upper head arising from the bony surface extending from the ridge on the great wing of the sphenoid bone to the base of the pterygoid process, and the lower head from the outer surface of the external pterygoid plate. The fibres composing these two portions converge to be attached to the front of the neck of the lower jaw and inserted into the fibro-cartilage above the condyle. The *internal pterygoid muscle* arises mainly from the pterygoid fossa, receiving slips from the adjacent tuberosities of the palate and superior maxillary bones. The internal pterygoid muscle closely resembles the masseter in form and in the direction of its fibres, which are inserted by a strong, broad tendon into the inner side of the ramus of the lower jaw, between the dental foramen and the angle. At their origins the pterygoid muscles rest upon and cross each other. When the muscles upon both sides of the head act in unison the lower jaw is drawn forward, so as to advance the lower teeth beyond the upper; when they act in alternation they serve as the direct agents in the trituration of food. The motor nerves to both of the pterygoid muscles are derived from the inferior maxillary nerve, like those to the masseter and temporal muscles. Trismus, or spasm, is very apt to affect the muscles of mastication, and may be produced by irritation of the sensory branches of the inferior maxillary nerve. The outer surface of the internal pterygoid muscle is in close relation with the internal lateral ligament of the temporo-maxillary joint, and its inner surface is associated with the tensor palati muscle, and is separated from the pharynx by a cellular space. Between the maxillary insertions of the two pterygoid muscles pass the vessels and nerves.

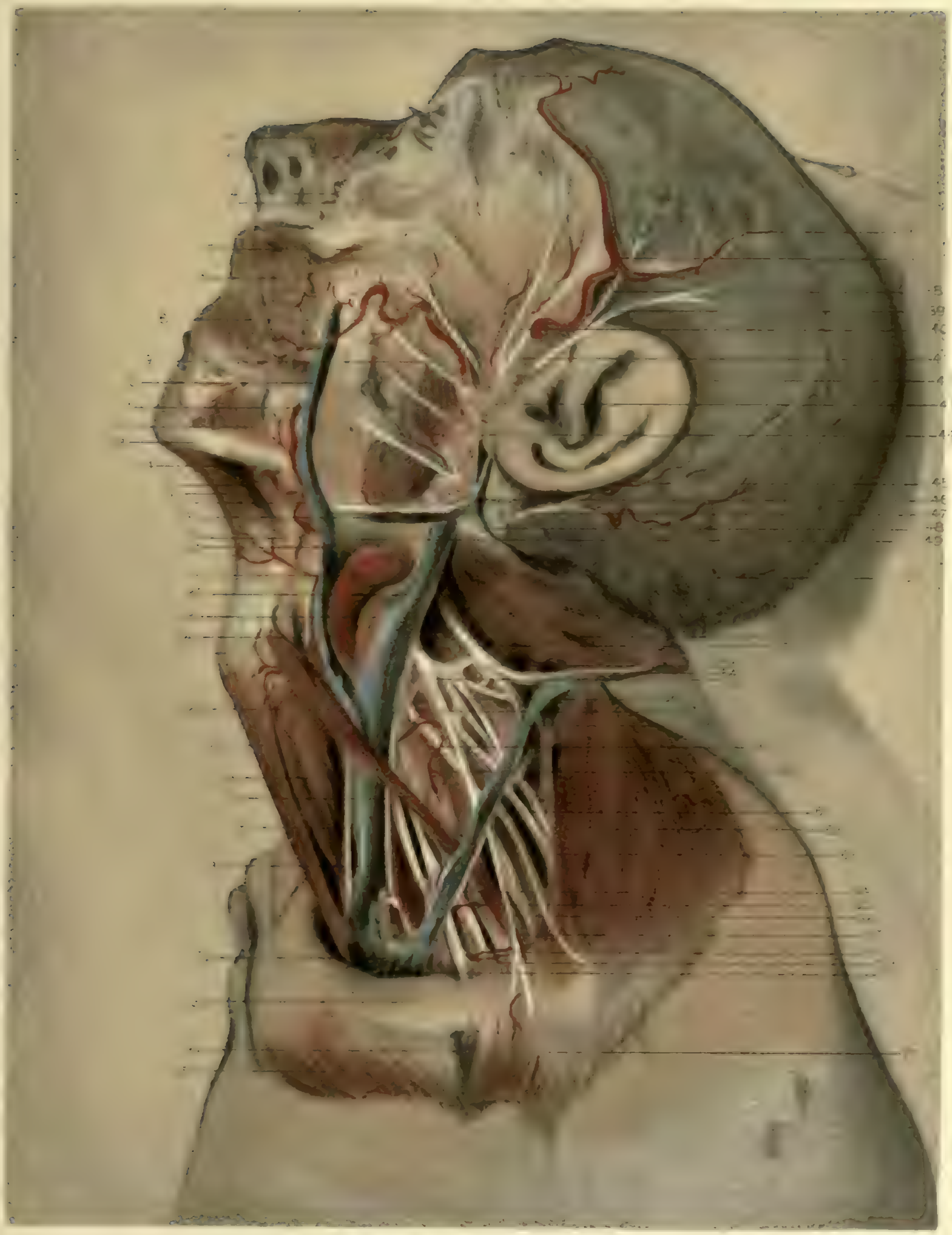
The *internal maxillary artery* arises from the external carotid artery in the substance of the parotid gland (page 130), opposite the neck of the lower jaw. It is very complex in its course, supplying numerous branches which establish free anastomoses with other arteries of the face and head (Plate 3, Fig. 2, and Plate 22, Fig. 2). In relation to the neck of the jaw, and between it and the internal lateral ligament, the artery just after its origin sends off the tympanic, middle and lesser meningeal, and inferior dental branches.

The *tympanic artery* enters the Glaserian fissure behind the articulation of the jaw, to supply the cavity of the tympanum and the membrana tympani, as described in the region of the ear. It also sometimes sends a little branch through a foramen in the anterior wall of the external auditory meatus, to supply the skin lining that canal. The *middle meningeal artery* ascends behind the external pterygoid muscle and enters the foramen spinosum of the sphenoid bone, whence it passes to the anterior inferior angle of the parietal bone and subdivides into radiating branches between the dura mater and the parietes of the skull (Plate 9, Fig. 2). The *lesser meningeal artery* usually arises independently from the internal maxillary, although it is often a branch of the middle meningeal. It enters the foramen ovale of the sphenoid bone, which also gives exit to the inferior maxillary nerve, and supplies chiefly the Gasserian ganglion of the trifacial nerve. The *inferior dental artery* descends to the dental foramen at the middle of the inner surface of the ramus of the jaw, which it enters with the dental nerve, and, passing through a canal in the diploic structure of the jaw, supplies the roots of all the teeth, eventually making its exit upon the face at the mental foramen (page 127) and becoming the *mental artery*. Before the inferior dental artery enters the dental foramen the mylo-hyoid branch is given off, accompanying the corresponding nerve to the mylo-hyoid muscle. In relation to the external pterygoid muscle the internal maxillary artery is very tortuous. It passes either over or under the muscle (in some cases through it), and subdivides into the masseteric, anterior and posterior deep temporal, external and internal pterygoid, and buccal branches. The *masseteric artery* passes outward through the sigmoid notch of the jaw to the under surface

PLATE 20.

Dissection of the vessels and nerves of the scalp and face on the left side, and the sterno-mastoid muscle removed from its sternal and clavicular attachments to display the deep cervical plexus of nerves. The fascial slip to the centre of the omo-hyoid muscle is also removed to show the relations of the common carotid artery and the internal jugular vein.

1. The anterior branch of the temporal artery.
2. The angular artery.
3. The compressor naris muscle.
4. The lateral nasal artery and vein.
5. The levator labii superioris muscle.
6. The zygomaticus major muscle.
7. The orbicularis oris muscle.
8. The transverse facial artery.
9. The infra-orbital branch of the facial nerve.
10. The facial vein.
11. The facial artery.
12. The depressor labii inferioris muscle.
13. The body of the lower jaw.
14. The sub-mental artery.
15. The anterior belly of the digastric muscle.
16. The mylo-hyoid muscle.
17. The facial artery, coming out of the submaxillary gland, in front of the masseter muscle.
18. The submaxillary vein, connecting the facial vein with the external jugular vein.
19. The position of the hyoid bone.
20. The oblique vein, connecting the facial vein with the internal jugular vein.
21. The external carotid artery, just above its origin, and slightly enlarged, as it is often found to be here.
22. The internal jugular vein.
23. The internal carotid artery, covered by its sheath.
24. The superior laryngeal artery.
25. The thyroid notch.
26. The anterior belly of the omo-hyoid muscle.
27. The left sterno-hyoid muscle.
28. The left sterno-thyroid muscle.
29. The phrenic nerve.
30. The pneumogastric nerve, brought forward into prominence.
31. The scalenus anticus muscle.
32. The junction of the external and internal jugular veins with the subclavian vein.
33. The clavicle.
34. The inter-muscular cleft between the great pectoral and deltoid muscles.
35. The pectoralis major muscle.
36. The posterior branch of the temporal artery.
37. The temporal artery.
38. The auriculo-temporal nerve.
39. The superficial temporal nerves.
40. The temporal branch of the facial nerve.
41. The upper border of the parotid gland.
42. The superior auricular muscle.
43. The remains of the parotid gland.
44. The masseter muscle.
45. The posterior auricular artery.
46. The temporal vein.
47. The posterior auricular nerve.
48. The external jugular vein, drawn aside, with the upper portion of the sterno-mastoid muscle.
49. The submaxillary gland.
50. The occipital artery.
51. The upper portion of the sterno-mastoid muscle drawn outward.
52. The second cervical nerve.
53. The anterior branch of the second cervical nerve.
54. The mastoid nerve.
55. The third cervical nerve.
56. The nerve to the levator anguli scapulæ muscle.
57. The anterior branch of the third cervical nerve.
58. The anastomosing branch of the second cervical nerve, with the spinal accessory nerve.
59. The fourth cervical nerve.
60. The scalenus medius muscle, with the ascending cervical artery.
61. The acromial nerve from the fourth cervical nerve.
62. The trapezius muscle.
63. The clavicular nerve from the fourth cervical nerve.
64. The sternal nerve from the fourth cervical nerve.
65. The transversalis colli artery.
66. The posterior belly of the omo-hyoid muscle.
67. The brachial plexus of nerves.
68. The supra-scapular artery.
69. The point of entrance of the thoracic duct.
70. The point of entrance of the external jugular vein with the subclavian vein.
71. The fascia over the deltoid muscle.



of the masseter muscle; the *deep temporal arteries* ascend to the under surface of the temporal muscle; the *pterygoid arteries* supply the pterygoid muscles; and the *buccal artery* passes with the buccal nerve to the buccinator muscle. After leaving the external pterygoid muscle the internal maxillary artery is continued through the spheno-maxillary fossa, where it gives off many terminal branches.

At the tuberosity of the superior maxillary bone the *superior dental artery* is distributed by minute twigs to the pulps of the molar and bicuspid teeth of the upper jaw, and to the contiguous portions of the gums and the antrum of Highmore. The *infra-orbital artery* passes upward through the spheno-maxillary fissure and enters the canal with the infra-orbital nerve, which it accompanies in its distribution, to emerge upon the face at the infra-orbital foramen (Plate 3, Fig. 2, No. 8). Within the canal the *anterior dental* branches descend to the incisor and canine teeth, and filaments ascend to the inferior oblique and rectus muscles, as well as to the lachrymal gland. The *descending palatine artery*, comparatively large, enters the posterior palatine canal with the palatine nerve from Meckel's ganglion, and runs along the roof of the mouth in close relation to the alveoli supplying the gums, the glands, and the mucous membrane over the soft and the hard palate (Plate 13, Fig. 4, No. 12).

The *Vidian artery* accompanies the Vidian nerve. It is not constant, and is always insignificant. The *pterygo-palatine artery* passes through the canal from which it receives its name, and supplies the Eustachian tube particularly. The *nasal*, or *spheno-palatine, artery* enters the nose with the nerve of the same name from Meckel's ganglion, supplying the ethmoidal cells, the turbinated bones, and the antrum, and terminates as the *septal artery*. It is noteworthy that the branches of the internal maxillary artery in the first and the last part of its course pass through bony canals, but that the branches from the intervening part go directly to muscles.

The *internal maxillary vein* is formed by the veins which bring back the waste blood from the territories supplied by the corresponding branches of the internal maxillary artery. These tributaries form a plexus—the *pterygoid plexus*—in the space between the temporal and external pterygoid

muscles, which establishes communications with the cavernous sinus above, at the base of the brain, and anteriorly with the facial vein. The vein unites with the temporal vein in the substance of the parotid gland, and they empty together into the external jugular vein.

The nerves which accompany the superior maxillary branches of the internal maxillary artery in their distribution are branches of the *superior maxillary nerve*, which is the second division of the fifth cranial or trifacial nerve. It leaves the skull through the foramen rotundum, passes horizontally forward across the spheno-maxillary fossa, and enters the orbit by the fissure of the same name. Within the spheno-maxillary fossa and just below the superior maxillary nerve is situated the **spheno-palatine** or **Meckel's ganglion** (Plate 3, Fig. 2, No. 6). It is a reddish-gray, heart-shaped body, about the size of a pea. Its *sensory* root is received from the spheno-palatine branches of the superior maxillary nerve; its *motor* root comes from the facial nerve, through the great petrosal portion of the Vidian nerve, and its *sympathetic* root through the sympathetic fibres of the Vidian nerve, derived from the carotid plexus. The nerves from Meckel's ganglion are distributed to the orbit, the palate, the nose, and the pharynx, and are described with the anatomy of those regions. The *Vidian nerve* is formed by the great petrosal branch of the facial nerve (page 69), reinforced by fibres from the carotid sympathetic plexus as it passes forward to the body of the sphenoid bone, which it enters and traverses through a special canal, the Vidian, to join the back part of the ganglion of Meckel.

The *inferior maxillary nerve* is one of the most interesting of the cranial nerves, from its resemblance to a spinal nerve (page 41). It is the largest branch of the great trifacial or fifth cranial nerve (Plate 3, Fig. 2), and is composed of sensory and motor filaments, owing to the union of the proper (sensory) portion of the nerve, from the lower angle of the Gasserian ganglion, with the distinct motor root of the trifacial nerve, just after its exit through the foramen ovale. The foramen ovale is five centimetres, or about two inches, from the outer surface of the head, on a level with the middle of the zygomatic arch. The inferior maxillary nerve is covered by the external pterygoid muscle, and is at the outer side of the Eustachian

tube. Almost immediately after the formation of the trunk of the nerve, as above described, it subdivides into two portions,—the *anterior*, consisting mainly of motor fibres, which are distributed to the muscles of mastication and to the buccinator, and the *posterior*, consisting chiefly of sensory fibres, which convey sensation to the teeth and gums of the lower jaw, the skin about the temple and external ear, and the lower part of the face and under lip. The *motor* branches, from the anterior portion, have each been described with the muscles which they furnish with power. The *sensory* auriculo-temporal branch has also been described in detail in its relations to the parotid gland and its distribution upon the side of the head. Its peculiar origin, from two roots which surround the middle meningeal artery and then unite to form a single nerve-trunk, should be remembered. The other important sensory branches are the inferior dental nerve and the lingual nerve. The *inferior dental nerve* leaves the trunk of the inferior maxillary nerve beneath the external pterygoid muscle, and descends to the dental foramen, by which it enters the inferior maxillary bone and accompanies the dental artery in its distribution to the pulps of the lower teeth (Plate 3, Fig. 2) and the adjoining gums. At the mental foramen the nerve divides into mental and incisor branches in relation to the divisions of the mental artery. The *mylo-hyoid nerve*, which supplies motion to the mylo-hyoid muscle and the anterior portion of the digastric muscle, appears to branch off from the inferior dental nerve just as that nerve is about to enter the dental foramen. This nerve derives its fibres from the motor root of the trifacial nerve, and is included in the sheath of the dental nerve for a short distance.

The *lingual nerve* is at first in close relation with the inferior dental nerve beneath the external pterygoid muscle, and is very deeply situated through its entire course. About on a level with the entrance of the dental nerve into the dental foramen the lingual nerve is joined by the *chorda tympani nerve* (page 69), which issues from the canal of Huguier, close to the Glaserian fissure. The lingual and inferior dental nerves are frequently connected by a communicating branch underneath the internal maxillary artery. The lingual nerve descends obliquely from the pterygoid region to the inner side of the last molar tooth of the lower jaw, being here

placed under the mucous membrane. In this situation it is sometimes divided to relieve the excruciating pain in cancer of the tongue.

The otic ganglion is an oval, reddish-gray little body situated internal to the inferior maxillary nerve, just below the foramen ovale. It is best found by tracing up the highest attachment of the internal pterygoid muscle until the nerve to that muscle is reached. By following along this nerve the ganglion will be found about its origin. It is very near the cartilaginous portion of the Eustachian tube, and the middle meningeal artery mounts upward behind it. The *motor* roots of the otic ganglion are derived from the internal pterygoid nerve, and the *sensory* root probably comes from the glosso-pharyngeal nerve; the *sympathetic* root is derived from the plexus which surrounds the middle meningeal artery. The ganglion is brought into relation with the facial nerve by the small petrosal nerve from the tympanic plexus (page 69). It sends a communicating branch to the auriculo-temporal nerve in its distribution to the parotid gland. It also sends off filaments to the chorda tympani nerve and to the tensor palati and tensor tympani muscles.

The superior maxillary region consists of the superior maxillary bones and the muscles, vessels, and nerves which they support. These have been described with the general anatomy of the face and pterygo-maxillary region. The *superior maxillary bones* are peculiarly constructed, being exceedingly fragile themselves, but very firmly connected by sutures to the other bones of the face. They are irregular in shape, assist in the formation of the cavities of the orbits, the nose, and the mouth, and are hollowed in their central portions, forming the *maxillary sinuses*, or *antra of Highmore*. Each antrum is developed very early in life, but it is not until the period of second dentition that the cavity assumes its full growth. Its facial, orbital, and nasal walls are very thin, and often yield to the pressure of growths or collections of fluid within it. The *facial wall* upon its external surface presents the *incisive fossa*, *canine eminence*, and *canine fossa* (Plate 28), which afford attachment to many of the muscles which act upon the nose, the upper lip, and the corners of the mouth (Plate 15). The *infra-orbital foramen* is above the canine fossa, and transmits the facial terminations of the superior maxillary nerve and the internal

maxillary artery. The *orbital wall* or *roof* of the antrum is grooved upon the middle of its orbital surface for the lodgement of the above-mentioned artery and nerve. This groove, two centimetres, or about a finger's breadth, from the margin of the orbit, terminates in a canal which soon subdivides into two branches, one of which, the *infra-orbital canal*, continues forward to open on the facial surface below the curved border of the orbit, giving passage to the *infra-orbital vessels* and *nerves*, and the other, the *anterior dental canal*, bends downward into the anterior portion of the antrum, transmitting the anterior dental vessels and nerves to the front teeth of the upper jaw.

The *nasal wall* of the antrum is an incomplete partition between the cavities of the antrum and nose. The further relations of this portion of the superior maxilla are described with the formation of the nasal cavities in the region of the nose.

The cavity of the antrum is often crossed by bony shelf-like projections similar to those found in the cranial sinuses, and on its posterior wall are the *posterior dental canals*, which convey the posterior dental vessels and nerves to the back teeth of the upper jaw (Plate 3, Fig. 2). The *floor* of each antrum is formed by the *alveolar process*, which is the thickest portion of the superior maxillary bone, is spongy in character, and is excavated into eight little pits on each side, forming the *alveoli*, or sockets, for the corresponding teeth. These alveoli vary in size and depth, that for the canine tooth being the deepest, while those for the molars are the broadest. They encroach upon the cavity of the antrum, and especially the alveoli for the first and second molars, the fangs of which have sometimes been found to penetrate directly into the antrum, a fact which has been taken advantage of in the extraction of one of these molars to drain or explore the antrum. The knowledge of the relations of the various processes of the upper jaw-bone—*i.e.*, the nasal, malar, alveolar, and palate processes—is of great value when surgical interference is required in the many affections to which this bone is liable. In *excision* of this bone it should be understood that its sutural connections with the contiguous bones by these processes are so strong that they must be severed by the use of the saw or bone-nippers.

PLATE 21.

Deep dissection of the head and neck on the right side to show the temporal muscle uncovered by its fascia, and the relative positions of the deep cervical and brachial plexuses of nerves.

1. The cut margin of the temporal fascia.
2. The temporal muscle.
3. The ridge for the temporal fascia.
4. The posterior auricular artery.
5. The branches of the occipital artery.
6. The occipital artery.
7. The upper portion of the sterno-mastoid muscle, turned upward.
8. The mastoid nerve from the second cervical nerve.
9. The external jugular vein, drawn outward.
10. The anastomosing branch of the mastoid nerve with the spinal accessory nerve.
11. The second cervical nerve.
12. The third cervical nerve.
13. The spinal accessory nerve.
14. The anterior branch of the third cervical nerve.
15. The fourth cervical nerve.
16. The trapezius muscle.
17. The acromial nerve from the fourth cervical nerve.
18. The clavicular nerve from the fourth cervical nerve.
19. The posterior belly of the omo-hyoid muscle.
20. The right clavicle.
21. The middle cord of the brachial plexus of nerves.
22. The point of entrance of the external jugular vein into the subclavian vein.
23. The deltoid muscle covered with the deep fascia.
24. The compressor naris muscle.
25. The lateral nasal artery and vein.
26. The facial branches of the facial nerve.
27. The superior labial artery.
28. The *pes anserinus* of the facial nerve.
29. The orbicularis oris muscle.
30. The facial vein.
31. The masseter muscle.
32. The facial artery.
33. The depressor labii inferioris muscle.
34. The inferior labial artery.
35. The mylo-hyoid muscle.
36. The anterior belly of the digastric muscle.
37. The hypoglossal nerve.
38. Fascia over the submaxillary gland.
39. The submaxillary vein, joining the facial vein with the external jugular vein.
40. The posterior belly of the digastric muscle.
41. The descendens hypoglossi nerve.
42. The superior laryngeal nerve.
43. The pneumogastric nerve.
44. The point of bifurcation of the common carotid artery into the external and internal carotid arteries.
45. The internal jugular vein.
46. The common carotid artery.
47. The thyroid notch.
48. The oblique vein joining the facial vein with the internal jugular vein.
49. The communicating branch of the third cervical nerve with the descendens hypoglossi nerve.
50. The anterior belly of the omo-hyoid muscle.
51. The anterior jugular vein.
52. The sterno-hyoid muscle.
53. The sterno-thyroid muscle.
54. The left clavicle.
55. The supra-sternal notch.
56. The inter-muscular cleft, between the great pectoral and the deltoid muscles.
57. The pectoralis major muscle.

The arch of the upper jaw is formed by the union of the alveolar processes of the two superior maxillary bones, and corresponds to the horseshoe-shaped arch of the lower jaw, in which the alveolar process is continuous. The *palate process* extends inward from the base of the alveolar process, and forms by its upper surface the anterior part of the floor of the nasal cavity, and by its lower surface, with that of its opposite fellow, the roof of the mouth. Posteriorly the palate processes are serrated for articulation with the horizontal plates of the palate bones. The combination of these bony processes and plates constitutes the *hard palate,* which varies in height and shape in different individuals. The palate process is much thicker in front than it is behind, and is perforated by foramina for the passage of the nutrient vessels. The lower surface is concave, and roughened, presenting little depressions for the palatine glands (Plate 13, Fig. 4, No. 11), and a bony channel for the passage of the posterior palatine vessels and the palatine nerves from Meckel's ganglion. Where the roof of the mouth is formed by the juxtaposition of the two palate processes, there is a large opening in the middle line behind the incisor teeth, which is called the *anterior palatine canal.* This canal is divided by septa into four little foramina. Two of these, the anterior and the posterior, are the *foramina of Scarpa,* and transmit the left and right naso-palatine nerves respectively. The others, one on each side, are the *foramina of Stenson,* and give passage upward for the terminal branches of the posterior palatine vessels to the nasal cavities from the mouth. On the palatal surface of many skulls an imperfect suture can be traced arching behind the anterior palatine canal to the interval between the alveoli for the lateral incisor and canine teeth on each side. This indicates the original separation of the *premaxilla,* or *incisive bone,* which in some animals exists permanently. In the human embryo it has a distinct centre of ossific formation, but generally coalesces at an early date with the rest of the maxillary bone. When this palatal suture is present it has never been found accompanied by a sutural line of demarcation on the facial surface of the normal human bone. That the incisive portion of the jaw has a distinct origin becomes manifest when an arrest in its development occurs, occasioning *cleft palate.* This is sometimes double, the segments con-

taining the incisor teeth on both sides being disconnected from the rest of the palate by a chasm, and attached above to the vomer only: this condition is usually associated with double hare-lip.

THE REGION OF THE MOUTH.

The opening of the mouth is bounded by the *upper* and *lower lips*, which are soft and flexible, and consist chiefly of the orbicularis oris muscle interlacing with fasciculi from the surrounding facial muscles (Plate 15). The lips are covered outwardly by the skin, which is closely adherent and very thin at their borders, and inwardly by the loose oral mucous membrane. There is no fat in the extensive connective tissue of the lips, which allows of considerable swelling when these parts are inflamed; and they are very mobile, owing to their muscular structure being almost entirely independent of bony attachment. The lips are joined on each side, forming the *angles* or *corners of the mouth*, which are in relation to the first bicuspid teeth when the mouth is closed. There is great variability in the length and thickness of the lips, depending upon the peculiarities of age, sex, and race. The *vermilion* color of the borders of the lips is due to the translucent nature of the stratified epithelium with which they are covered, and through which the vascularity of the subjacent tissues, due to the numerous papillæ and capillary plexuses, can be seen. The lips are endowed with marked sensibility, through the presence of sensory papillæ, resembling tactile corpuscles, derived from the ultimate fibres of the infra-orbital nerves in the upper lip and from the mental nerves in the lower lip. The *coronary arteries* (page 124) ramify between the under surface of the orbicularis muscle and the mucous membrane, and form a free circular anastomosis around the inside of the lips. They are of large size, and can be readily felt pulsating on pressing the lips from within; and they are apt to be wounded by the teeth in consequence of a blow upon the mouth. When wounded it is usually found necessary to tie both ends of the cut vessels. The labial veins form a wide-meshed plexus in relation to the arteries. Owing to the vascularity of the lips, *nævi* frequently occur here; and it is worthy of mention in this connec-

tion that the lower lip is the most common seat of epithelioma. Embedded in the meshes of the submucous tissue, within the inner margins of the lips, there are many racemose mucous glands, the *labial glands*, which are arranged in a continuous zone, being most numerous in the centre of the upper lip. These glands are about the size of small peas, and their ducts open by small orifices upon the mucous membrane. The closure of the ducts of these glands produces the mucous cysts often found in this situation. There are folds of the mucous membrane on the inner side of the middle of each lip,—the *frœna labiorum*,—which connect the lips with the adjacent gums. The lips serve as organs of suction, prehension, and speech; and, from their varied associations with many of the expressions, they often constitute a characteristic feature. Sometimes a congenital fissure exists in the upper lip, from arrest of development: this is known as simple hare-lip. The space between the closed teeth and the inner surface of the lips and adjacent portions of the cheeks is called the *vestibule*. The *cheeks* form the sides of the face externally and of the mouth internally, and consist of two strata of muscular fibres, with a variable quantity of fatty tissue interposed. The outer layer of muscular tissue is formed by the zygomaticus and platysma muscles, over which the skin is loosely spread; and the deep muscular layer is the buccinator muscle, which has a fibrous sheath externally extending to the superior constrictor muscle of the pharynx and called the *bucco-pharyngeal fascia*. On the oral surface of the buccinator the mucous membrane is attached by a firm submucous connective tissue. The buccal mucous membrane is continuous with the lining of the cavity of the mouth, but it is thinner and less sensitive than that of the lips. It contains a number of little glands,—the *buccal glands*,—which resemble the labial glands in structure, but are smaller and are arranged in clusters, especially in relation to the second superior molar tooth, where the mucous membrane is pierced by the opening of Stenson's duct from the parotid gland. These are called the *molar glands*, and they are often involved in abscesses, or are subject to scirrhus-like nodules, in consequence of stoppage of their ducts. The cheeks are very elastic, and serve to keep the food between the teeth, mainly through the action of the buccinator muscles. They are also

vascular, both within and without. Within, the vessels in the submucous tissue form fine vascular plexuses; while without, the vessels are large and are superficial to the buccinator muscle. In relation to the anterior border of the coronoid process of the lower jaw, and between it and the tuberosity of the upper jaw, there is a recess in which a deep-seated abscess of the temporal region is prone to discharge, owing to the density of the overlying external fascia. This may be detected by the finger passed between the teeth and the cheek.

The mucous membrane reflected upon the arching alveolar borders of the jaws is closely adherent to the periosteum, and forms the *gums.* It is peculiarly modified, and contains dense masses of reticulated connective tissue, which surrounds and sends processes between the necks of the teeth. The gums are very vascular, and bleed freely upon laceration, furnishing most of the blood which follows the extraction of a tooth. They have very little sensibility, except when inflamed, and in health are smooth and of a pale pink color. They present fine papillæ around the margins of the alveoli, which secrete the *tartar,* and their peculiar vascularity occasions a red line which is often conspicuous in phthisical patients. In chronic lead-poisoning a blue line appears along their margins, from a deposition of sulphide of lead, produced by the sulphuretted hydrogen arising from the decomposition of particles of food retained between the teeth acting upon the lead circulating in the capillary vessels. The alveoli are lined with an inflection of the outer epithelial layer of the gums, which firmly adheres to their periosteal lining membrane.

The gums form a tough protecting covering to the developing teeth in infancy; and there is always a separation between them until the further development of the alveolar arches and the eruption of the teeth.

The small size of the facial portion of the skull at birth and during childhood is due to the rudimentary condition of the jaws and teeth. The upper and lower maxillary bones commence to ossify at a very early period, the lower maxillary first. They are developed very slowly, and undergo various modifications until their complete form is attained at puberty. There are two sets of teeth, both of which appear at different periods during childhood,—the first, called the temporary, giving way

to the second, called the permanent. The development of the temporary teeth in the fœtus begins with the first formation of the jaws,—about the seventh week.

The teeth are calcified papillæ of the mucous membrane. The stages of their development have been more carefully studied than perhaps those of the development of any other portion of the body at this period of life. Briefly stated, the process may be summed up as follows. The primitive dental groove is caused by a turning inward or depression of the oral epithelium, forming a furrow in the edges of the jaws, from the bottom of which a vascular ridge of papillæ springs up contemporaneously. Each of these papillæ gradually assumes the shape of a future tooth, and is covered with a cap of epithelial cells, which undergo a differentiation so as to form the dentine, the enamel, and the cement. The changes which take place in the bones of the jaws relate only to the formation of the sockets of the teeth. At first there is no appearance of alveoli; but as the changes by which the teeth are developed occur in the mucous membrane, there is a groove formed in the jaw itself, which by degrees becomes wider and is divided by thin bony partitions. The edges of the alveoli are turned toward one another shortly after birth, so as to protect the developing temporary teeth from injury. The germs of the *temporary teeth* make their appearance from the seventh to the twelfth week of embryonic life. They are not set vertically opposite one another in the two dental arches, the upper-jaw teeth being in front of the lower, a relative position which they maintain, after their eruption, throughout life. The temporary teeth are very imperfectly developed at birth, and are not fully formed until about the age of four and a half years. They number twenty,—four incisors, two canines, and four molars in each jaw. Their periods of eruption after birth are, approximatively, the central incisors about the seventh month, the lateral incisors from the eighth to the tenth month, the anterior molars from the twelfth to the eighteenth month, the canines from the fourteenth to the twentieth month, and the posterior molars from the eighteenth to the thirty-sixth month. The lower teeth generally precede the upper ones.

The *permanent teeth* consist of two groups,—those which have, and

those which have not, predecessors. To the former group belong the incisors, canines, and bicuspids; to the latter, the molars. The incisors, canines, and bicuspids directly succeed to the positions occupied by the temporary teeth, and correspond in number to them. The molars, three in number, on both sides of each jaw, are the additional permanent teeth. The development of the first group of the permanent teeth is effected in a manner analogous to that of the temporary teeth, a second dental furrow being formed out of the epithelial lining of the gums and vascular papillæ. In the process, the sac which encloses each tooth-germ becomes attached to the back of the sac of a temporary tooth. The three additional permanent teeth, the *molars*, are developed by successive prolongations of the epithelial tissue toward the angles of the jaws. The calcification of the permanent teeth extends from birth to about the twelfth year of life. The fangs, or roots, of the temporary teeth disappear by absorption as the permanent teeth develop, and the loose crowns gradually become detached, giving place to the new-comers. The eruption of the permanent teeth takes place usually as follows: the first molars at six and a half years, the middle incisors in the seventh year, the lateral incisors in the eighth year, the first bicuspids in the ninth year, the second bicuspids in the tenth year, the canines about the twelfth year, the second molars from the twelfth to the thirteenth year, and the third molars (wisdom teeth) from the eighteenth to the twenty-first year, or later. It is not practicable to keep all these facts in mind, but it should be remembered that the first tooth of the temporary set makes its appearance in the seventh month, and the first of the permanent set in the seventh year. The lower-jaw teeth precede the upper-jaw teeth, as in the temporary set. About the sixth year, before the temporary incisors are shed, the jaws contain all the temporary and permanent teeth, except the wisdom. During the growth of the teeth the lower jaw increases in depth and length and changes its form. At birth this bone consists of two lateral halves united by fibro-cartilage. The body is a mere shell of bone, and the angle of the jaw is obtuse. About the first year the two halves become joined at the symphysis. The jaw becomes gradually elongated behind the mental foramen, so as to accommodate the three extra permanent molars.

The angle also steadily becomes less obtuse until adult age is reached, when it is nearly a right angle. In old age it becomes again obtuse. The difference in width between the incisors of the temporary and permanent sets is compensated for by the smallness of the bicuspids in comparison with the temporary molars to which they succeed.

In the adult, the teeth are rarely found in a perfect state, owing to neglect or abuse. They are symmetrically arranged upon both sides of the jaws, and are thirty-two in number, eight above and eight below on each side. The four anterior teeth in each jaw are the *incisors*, the middle two of which are called the central and the outer ones on each side the lateral incisors. Next to the incisors are the *canines*, one on each side; behind these are the two *bicuspids*, or *premolars*, and last of all the three *molars*. Each tooth consists of a free surface, the *crown*, a *body*, a *neck*, which is embraced by the gum, and one or more *roots* or *fangs*, which are sunk into the alveoli. The crown of a tooth is covered with a cap of *enamel*, which is the hardest known animal substance, and the fang is covered by a layer of true bone tissue, called *cement*. The mass of any tooth is composed of a hard outer substance, *dentine*, or ivory, which is harder than bone, and encloses a *cavity* in which is lodged the gelatinous mass called the *pulp*. The pulp is exactly the shape of the tooth which contains it, and consists of a mass of fusiform cells, called *odontoblasts*, surrounded by the minute dental vessels and nerves, which enter the cavity through canals in the fangs (Plate 3, Fig. 2).

The *incisor teeth* are constructed for biting, having a crown shaped somewhat like a chisel, convex on the outer side and usually concave on the inner. They have a single, long, conical fang, which is slightly grooved at the sides. The crowns of the central incisors are three-pointed, until they are worn away by use, and they are rounded where they join their fangs. The lower incisors are more slender than the upper ones,—in fact, they are the smallest of all the teeth,—and their crowns are narrower, with a straighter cutting edge. The lateral incisors are shaped like the central incisors, although they are smaller, and in both jaws they correspond with each other in general character. The edges of the upper incisors overlap those of the lower in such a way that they are both worn away

PLATE 22.

Figure 1.

Dissection of the back of the neck to show the superficial muscles and the nerves and arteries in the occipital triangles.

1. The external occipital protuberance.
2. The left occipital artery.
3. The left occipitalis major nerve.
4. The left trapezius muscle.
5. The left splenius muscle.
6. The posterior auricular vein.
7. The left sterno-mastoid muscle.
8. The left occipitalis minor nerve.
9. The internal cutaneous branches of the second dorsal spinal nerve.
10. One of the dorsal cutaneous arteries, from the posterior branch of the second intercostal artery.
11. The right occipital artery.
12. The right occipitalis major nerve.
13. The right complexus muscle.
14. The right splenius muscle.
15. The right occipitalis minor nerve.
16. The right levator anguli scapulæ muscle.
17. The right rhomboideus minor muscle.
18. The posterior scapular artery.
19. The nerve to the levator scapulæ muscle.
20. The right rhomboideus major muscle.

Figure 2.

The deep parotid region. The malar bone and the ramus of the lower maxillary bone have been removed to show the parts beneath, involving the internal maxillary artery (or deep facial artery).

1. The infra-orbital artery.
2. The alveolar artery.
3. The inferior dental artery and nerve.
4. The facial artery and vein.
5. The submaxillary gland (partly dissected to show the facial vessels).
6. The lingual artery and hypoglossal nerve.
7. The superior thyroid artery and the superior laryngeal nerve.
8. The deep temporal artery.
9. The deep temporal nerve.
10. The middle meningeal artery.
11. The parotid gland partially removed.
12. The origin of the internal maxillary artery.
13. The posterior auricular artery.
14. The lingual branch of the fifth cranial nerve or (gustatory nerve).
15. The stylo-hyoid muscle.
16. The posterior portion of the digastric muscle.
17. The auricularis magnus nerve.
18. The internal carotid artery.
19. The external carotid artery.
20. The internal jugular vein.
21. The tendon of the digastric muscle in relation to the hyoid bone, the hypoglossal nerve, and the lingual artery.
22. The external jugular vein.
23. The common carotid artery, just below its bifurcation.

Fig 1

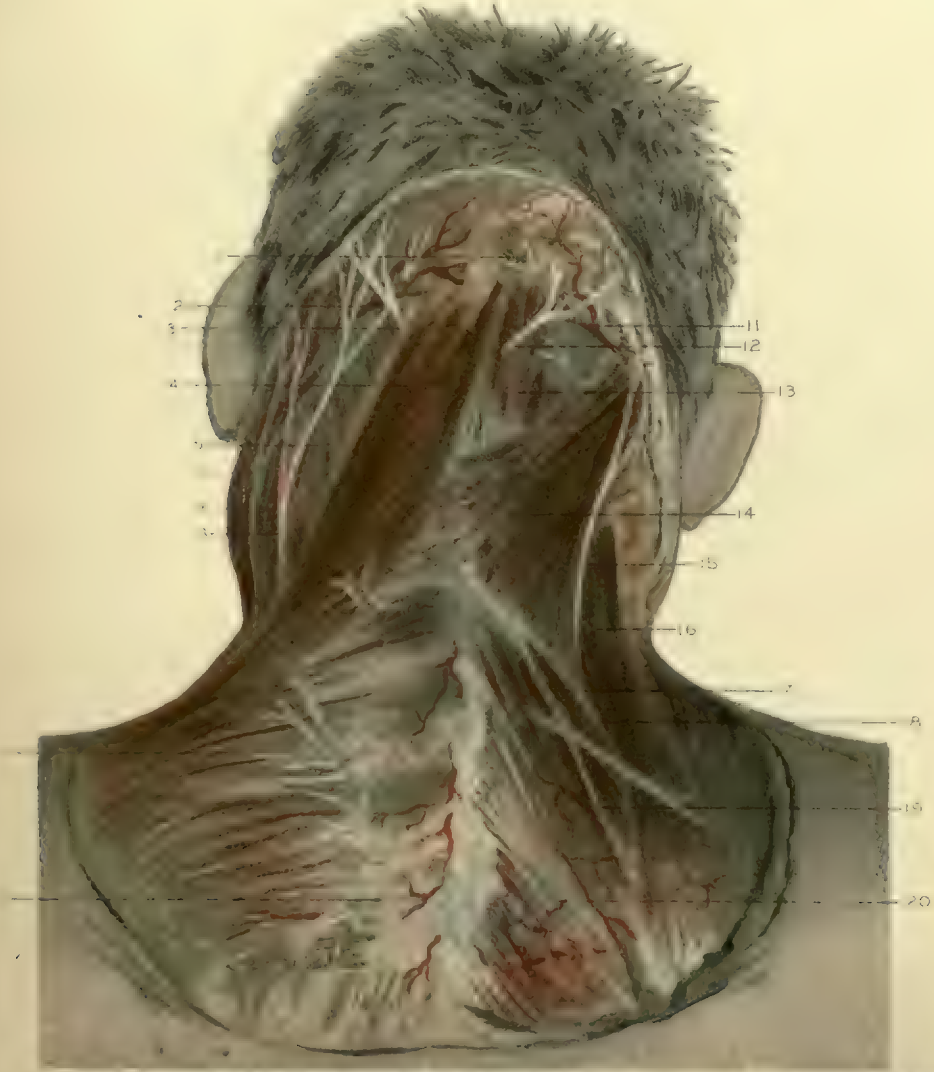
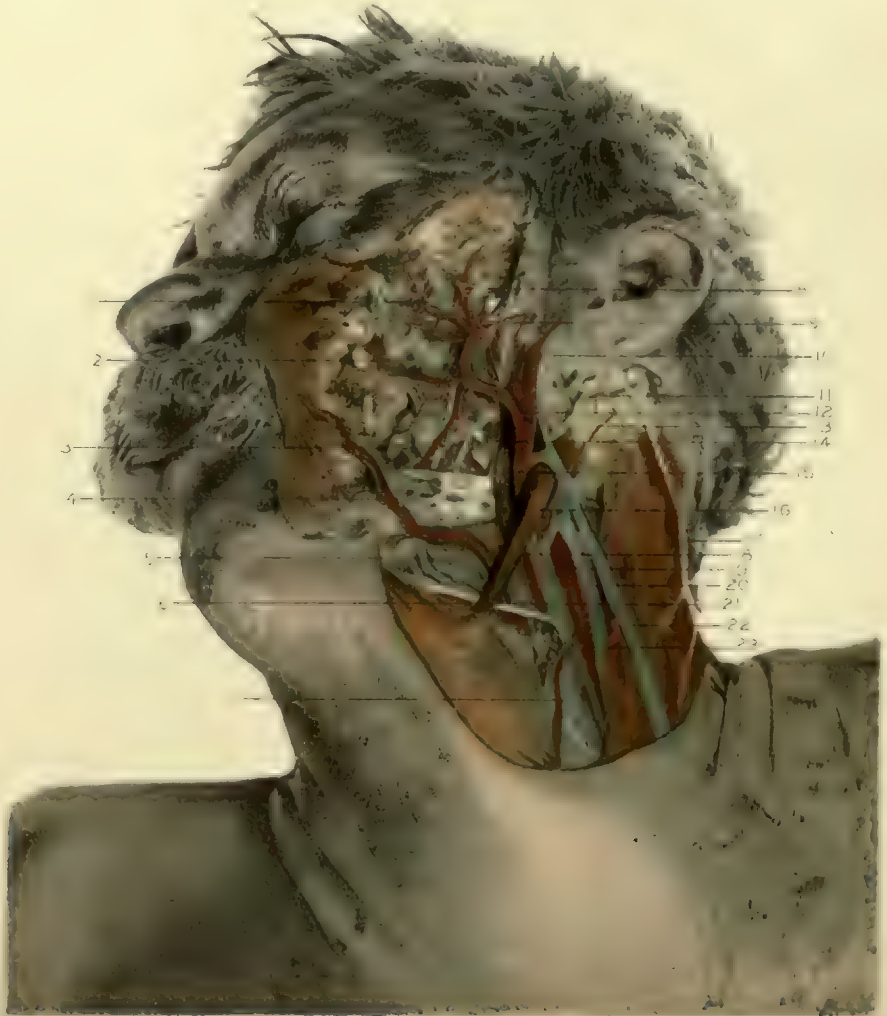


Fig 2



in a bevelled manner, which does not lessen their cutting power. The *canine teeth* are constructed for tearing, having a sharp-pointed crown, convex in front and slightly hollowed behind. They each have a single stout fang, which is longer than that of any other tooth, and sometimes enters the antrum. The lower canine teeth are smaller than the upper, with blunter points and shorter fangs. The canine teeth overlap each other so that the upper ones are worn upon their inner surfaces and the lower ones upon their outer. They become gradually blunted, and eventually their cutting borders are reduced nearly to the level of the incisors. The *premolars*, or *bicuspid teeth*, are shorter than the canines, and are provided with two cusps or tubercles on the crown, one of which, on the cheek side, is marked by a middle ridge. The cusp on the tongue side of the premolars is highest anteriorly. These teeth usually have only a single fang.

The *molar teeth* are the largest in size. Their crowns are rhomboidal in shape and have from three to five cusps, and each tooth has from two to four fangs. The cusps on the cheek side are smaller, higher, and sharper than those on the tongue side. The first upper molar has four cusps. The first lower molar has five cusps, three outer and two inner, and has two pulp-canals in its posterior fang. The second upper molar usually has only three cusps, two outer and one inner. Its outer fangs are often united. It is very variable. The second lower molar has four cusps, and has two pulp-canals in its posterior fang. The third upper molar has three cusps and very irregular club-shaped fangs. The lower third molar has, in addition to its four cusps, a rudimental cusp posteriorly on the cheek side.

When the teeth are brought in apposition, the upper teeth overlap the lower ones in front, while the surfaces of the molar teeth are in contact, so that the arch formed by the teeth of the upper jaw is slightly larger at the sides and in front than the arch formed by the teeth of the lower jaw. The last molars, or wisdom teeth, are the only teeth which are exactly in contact with one another, all the others having each two antagonists. The upper incisors overlap the lower ones and the adjacent sides of the canines, the bicuspid and molar teeth above and below alternating,

so that each has a bearing on two opposite teeth. By this arrangement, when one tooth is lost its fellow of the opposite jaw is still useful in mastication.

The cavity of the mouth (*cavum oris*) is bounded in front by the teeth and gums, above by the hard palate, behind by the soft palate and its arches and the opening into the pharynx, and below by the tongue and the mylo-hyoid muscles. The walls of the cavity are lined by mucous membrane, which is continuous with that of the vestibule over the surfaces of the gums, and is variously modified in the different localities. **The hard palate** is the vaulted *roof of the mouth* (Plate 12, No. 34, and Plate 13, Fig. 4, No. 1), formed by the union of the under surfaces of the palate processes of the superior maxillary bones (page 144). When the mouth is formed in the fœtus there is at first no separation between it and the nose; but the general cavity is gradually closed by the horizontal plates of the superior maxillary and palate bones advancing toward each other and the septum of the nose descending from above to join them in the middle line. Normally the only trace of the original fissures is the naso-palatine canal. The closure of the palate begins in front and extends backward, and is ordinarily accomplished from the eighth to the tenth week. What is called *cleft palate* is simply an imperfect closure of the fœtal gap in this region. The cleft is always in the middle line, and often involves the soft palate and the uvula. If the cleft in the hard palate includes the alveolar border, it leaves the middle line and follows the suture between the maxillary bone proper and the os incisivum. This defect is usually associated with a corresponding fissure in the upper lip, called *hare-lip*, which hardly ever occurs in the middle line, and is always opposite the interval between the lateral incisor and canine teeth at the intermaxillary suture. If the cleft in the palate extends on each side of the os incisivum—separating that bone completely—it is often accompanied by fissures on both sides of the upper lip,—*double hare-lip*. The mucous membrane covering the hard palate is so intimately connected with the periosteum that the two cannot be separated. In the middle line the membrane is comparatively thinner than along the borders of the alveoli, where it is quite thick and contains a compact layer of mucous

glands,—the *palatine glands* (Plate 13, Fig. 4, No. 11),—the orifices of which open upon the surface of the membrane and are especially numerous where the hard and soft palates blend into each other. The density of the muco-periosteal covering of the palate plays an important *rôle* in the operation for the remedy of cleft palate. The surface of the palatal mucous membrane is smooth posteriorly, but raised in transverse ridges anteriorly, and is divided by a slight raphé, which ends in a little papilla just behind the interval between the central incisor teeth.

The soft palate (*velum pendulum palati*) consists of a movable flap of muscular tissue covered with mucous membrane, which is directly continuous backward from the hard palate, from which it extends obliquely downward between the mouth and the posterior nares into the pharynx (Plate 12). From the middle of the soft palate a free conical process is suspended, called the *uvula* (Plate 13, Figs. 2, 3, and 4), from the sides of which two folds of mucous membrane, enclosing muscular fibres, arch outward on each side, connecting the palate with the tongue and the pharynx. These are the arches or *pillars of the palate.* The *anterior* pillars curve downward and forward to the tongue, while the *posterior* pillars curve downward and backward to the pharynx. The posterior surface of the soft palate is continuous with the floors of the nasal cavities, and in the act of swallowing it is lifted upward by the levatores palati muscles into apposition with the back of the pharynx, so as to close the posterior nares. A raphé exists in the median line of the uvula, prolonged from that of the hard palate, which indicates its original formation by two halves, and is the line of division when the soft palate is affected with cleft. The uvula varies in length according to the relaxation of its intrinsic muscles, and occasionally becomes permanently elongated, causing a tickling sensation in the throat and a distressing cough. The muscles of the soft palate are immediately under the mucous membrane; and a proper understanding of their relative position and function is of the utmost importance in all operations in this region, especially for the closure of cleft palate, as the action of some of them tends to widen the cleft, requiring their division before attempting to close it.

The *hamular process* of the internal pterygoid plate of the sphenoid

bone can be easily detected by the finger pressed upon the soft palate in close relation to the last upper molar tooth, and is a valuable landmark.

The *levatores uvulæ* (or *azygos*) are two little bundles of muscular fibres which hang side by side, suspended from the posterior nasal spine of the palate bone and from the palatal aponeurosis, and are covered with a loose reflection of the mucous membrane, forming the uvula, already mentioned.

The *levatores palati* arise from the under surfaces of the apices of the petrous portions of the temporal bones, and from the adjoining cartilaginous portions of the Eustachian tubes. After passing over the superior constrictor muscles of the pharynx their course is obliquely downward, and their fibres blend with the levatores uvulæ on their posterior surface. Their normal action is to raise the soft palate in deglutition, and they are powerful retractors of the flaps in cleft-palate operations. In order to divide either of these muscles, a narrow curved knife should be entered through the soft structures half-way between the hamular process and the Eustachian tube and an oblique incision made outwardly.

The *tensores palati*, or *circumflexi*, muscles are situated, one on each side, externally to the levatores palati. They are interposed between the internal pterygoid muscles and the internal pterygoid plates of the sphenoid bone, arising mainly from the scaphoid fossæ and spines of that bone. Some of their fibres also come from the contiguous vaginal processes of the temporal bones and the outer sides of the Eustachian tubes. From these broad origins the muscles descend on each side perpendicularly to the hamular processes, where they become somewhat tendinous and are held in position by bands of connective tissue and lubricated by synovial bursæ. Thence they take an inward direction, and, approaching each other, their fleshy fibres interlace on the anterior surface of the base of the uvula, while the tendinous fibres are inserted into the horizontal plates of the palate bones. The function of these muscles is to render the palate tense, and they also oppose the closure of a breach extending through it. Their division may be effected, on either side, by introducing a narrow knife with the edge upward just along the inner side of the hamular

process and cutting upward a few lines. If the knife in this operation is pressed against the posterior surface on its withdrawal, the levator palati may be cut also, but this latter muscle is better cut *transversely*, as described before, as its retractive power is greater than that of the tensor.

The muscles which are contained within the mucous folds of the pillars of the palate are the palato-glossi anteriorly and the palato-pharyngei posteriorly. The *palato-glossi muscles* arise from the anterior surface of the soft palate, interchanging fibres with each other across the base of the uvula, and curve downward and forward, to be inserted into the sides and dorsum of the tongue, blending with the fibres of the stylo-glossi muscles. The *palato-pharyngei muscles* each arise from the soft palate by two fasciculi, which embrace the levatores palati in their relation to the uvula, and also interchange fibres with each other. Besides these fibres of origin, a slip from the neighboring Eustachian tube, called the *salpingo-pharyngeus,* often joins each muscle. The palato-pharyngei are directed backward, and, blending with the fibres of the inferior constrictor and stylo-pharyngei muscles, are inserted into the posterior borders of the thyroid cartilages. These muscles aid the levatores and tensores palati in drawing apart the flaps after the operation of staphylorrhaphy, and their division consists in simply cutting across the posterior pillars, just below the tonsils, with blunt-pointed scissors.

The principal *arteries* of the hard and the soft palate are the posterior palatine branches of the internal maxillary arteries (page 141), which. after passing down the posterior palatine canals, emerge from the posterior palatine foramina and run along close to the alveolar borders to the anterior palatine canal (Plate 13, Fig. 4, No. 2). In dissecting off the muco-periosteal flaps to cover a cleft palate the lateral incisions should be made as close as possible to the alveoli, in order to preserve these vessels and secure the vitality of the flaps.

The pillars and back of the soft palate also receive blood on each side from the ascending pharyngeal artery and from the ascending palatine branches of the facial artery. The latter vessel is in close relation to the levator palati muscle, and is the chief source of bleeding after division of

PLATE 23.

Figure 1.

The skin removed from the anterior region of the neck to show the platysma myoides muscle and the superficial cervical veins.

1. The median raphé.
2. The right thyro-hyoid muscle, seen through the superficial fascia.
3. The anterior border of the right sterno-mastoid muscle.
4. The right external jugular vein.
5. The anterior jugular vein, occupying the middle line.
6. The clavicular and acromial nerves.
7. A perforating thoracic artery.
8. The anterior border of the left sterno-mastoid muscle.
9. The platysma myoides muscle.
10. Superficial transverse veins.
11. The left external jugular vein.
12. The clavicular nerve.
13. The anterior perforating thoracic artery.

Figure 2.

The anterior cervical muscles, in relation to the veins, arteries, and nerves. The median raphé has been cut through and the anterior thyroid muscles separated to display the nerves over the larynx and trachea.

1. The right facial artery and vein.
2. The anterior portion of the right digastric muscle.
3. The facial artery tunnelling the submaxillary gland.
4. The oblique vein, connecting the external and internal jugular veins.
5. The thyroid notch.
6. The right thyro-hyoid muscle.
7. The right common carotid artery, just below its bifurcation.
8. The right internal jugular vein.
9. The trunk of the right superior thyroid artery, passing beneath the sterno-thyroid muscle.
10. The crico-thyroid artery and vein.
11. The superficial cervical plexus of nerves on the sterno-mastoid muscle.
12. The transverse cervical nerve.
13. The right external jugular vein.
14. The right omo-hyoid muscle.
15. The right sterno-hyoid muscle.
16. The right sterno-thyroid muscle.
17. The sternal nerve.
18. The external jugular vein, where it passes into the subclavian vein.
19. The sternal end of the right sterno-mastoid muscle.
20. The supra-sternal notch.
21. The left facial artery and vein.
22. The anterior portion of the left digastric muscle.
23. The left facial artery, coming out of the submaxillary gland.
24. The body of the hyoid bone.
25. The thyro-hyoid membrane.
26. The left omo-hyoid muscle.
27. The left external carotid artery.
28. The left internal carotid artery.
29. The left internal jugular vein.
30. The position of the cricoid cartilage.
31. The superficial cervical plexus of nerves.
32. The left sterno-mastoid muscle.
33. The descending branches of the superior thyroid arteries.
34. The anterior jugular vein.
35. The left sterno-hyoid muscle.
36. The left external jugular vein.
37. The margin of the left sterno-thyroid muscle.
38. The clavicular nerves.
39. The sternal end of the left sterno-mastoid muscle.

Fig 1


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Fig 2


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this muscle. The palatine nerves (from Meckel's ganglion) accompany the posterior palatine vessels.

The tensor palati muscle receives a special nerve from the otic ganglion, which enters the muscle on its posterior surface.

The tongue is the freely movable muscular organ occupying the cavity of the mouth, designed to assist the various offices of mastication, deglutition, taste, and speech. When the mouth is closed, the upper surface, or *dorsum*, of the tongue is convex, conforming somewhat to the palatal roof, and the point, or *tip*, lies behind the lower incisor teeth (Plate 12). The back, or *root*, of the tongue is attached to the hyoid bone, and it is supported on each side by a sling of muscles from the styloid process of the temporal bone and the anterior palatine arches. The under surface of the organ is connected to the symphysis of the lower jaw. The mucous membrane covering the upper surface of the tongue is provided with a thick layer of stratified epithelium, which is being constantly renewed. The *furring* or *coating* of the tongue, as it is commonly called, consists of detached epithelium commingled with fungi of peculiar and variable growth, according to the state of the digestive canal. The appearance of the tongue is an important guide to the physician, and merits very close scrutiny. The dorsum of the tongue is divided by a *raphé* into symmetrical halves, which end, at the level of the isthmus of the fauces, in a depression, the *foramen cæcum*, which is the common opening of several large mucous glands. The posterior third of the upper surface of the tongue is quite smooth compared to the anterior two-thirds, which are rough and covered with *papillæ* of several distinct kinds. These papillæ are supported in a layer of connective tissue, the *corium*, which is thicker and looser posteriorly than it is anteriorly, where it is very closely adherent to the muscular tissue. The corium is composed of a dense net-work of connective and elastic tissue, continuous with the intermuscular septa, and contains the vessels, nerves, and lymphatics which are associated with the papillæ.

The *papillæ circumvallatæ* (Plate 13, Fig. 4, No. 9) are much the largest, and vary from eight to twelve in number. They are arranged upon the back of the tongue in two rows, one upon each side, which

converge toward the *foramen cæcum*, resembling in shape the letter V inverted. Each of these papillæ is a conical body, inverted, with its apex resting in a little fossa, and its base presenting on the surface of the tongue covered with papillæ, into each of which can be traced with the microscope filaments from the glosso-pharyngeal nerve and branches from the dorsal artery of the tongue. The epithelial lining of these papillæ, as well as of the walls of the fossæ which contain them, encloses numerous flask-shaped bodies, called *taste-buds.* The general velvety appearance of the tongue is due to the numberless *filiform papillæ* which are spread over its surface. These papillæ consist of conical processes, which terminate in free, hair-like villi, and are mostly arranged in rows parallel to the circumvallate papillæ. The points of the filiform papillæ are directed backward, so that they give a rough sensation to the finger if it is passed over the tongue from behind forward. Scattered over the sides and tip of the tongue, throughout the filiform papillæ, are the *papillæ fungiformes* (Plate 13, Fig. 4, No. 10), so called because they resemble little mushrooms. At the point of the tongue they are most numerous, and are always of a bright red color. In many of the exanthematous fevers these fungiform papillæ become hypertrophied and their color intensified. The fungiform papillæ contain capillary loops and nerve filaments from the lingual branch of the inferior maxillary nerve, which terminate in taste-buds. The taste-buds are composed of a congeries of flattened *support-cells,* which enclose the so-called *gustatory cells.*

The mucous membrane on the under surface of the tongue is smooth, thin, and loose, and presents several distinct folds. In front, in the middle line, there is a fold reflected from the tongue to the inner surface of the gum, called the *frænum linguæ.* Sometimes the frænum is continued farther forward than usual, or may be abnormally short, producing the condition known as "tongue-tie," which is attended by a lisping of the speech. This can be easily remedied by snipping the free border of the frænum with blunt-pointed scissors as close to the jaw as possible, so as to avoid wounding the ranine vessels, which are contained within the elevated fringes of mucous membrane on the under surface of the tongue, extending on each side of the frænum toward its tip. The ranine artery lies deeper

than the vein on each side. If the frænum and subjacent muscular fibres be too freely divided in operating for tongue-tie, there is danger of a child, in its efforts at sucking, tearing these lax fibres farther open, so that the tongue may be forced down upon the epiglottis by the muscles of deglutition and occasion suffocation.

At the sides of the tongue the mucous membrane is reflected to the body of the lower jaw, and covers over the mylo-hyoid muscles, forming the floor of the mouth. At the back of the tongue there are folds passing on each side to the soft palate, which enclose the palato-glossi muscles, and there are also three folds to the epiglottis, a *right* and a *left glosso-epiglottic fold* and a posterior median, the *frænum epiglottidis.* The latter serves to raise the epiglottis when the tongue is protruded (Plate 13, Fig. 4), a fact which is taken advantage of by drawing out the tongue, so as to open the pharyngeal air-passages, when a patient under ether breathes stertorously. The orifices of the submaxillary ducts open upon elevations of the mucous membrane close to the borders of the frænum linguæ; and the orifices of the sublingual ducts are in the furrows between the sides of the tongue and the gums. There are a number of mucous glands in the submucous tissue of the tongue, especially about its root, which resemble the labial and buccal glands (page 149). Beneath the apex of the tongue, on each side of the frænum, there is a group of glands which are supposed to be salivary. There is a considerable amount of connective tissue, as well as of lymphoid tissue, in the substance of the organ. The latter is found chiefly at its root. To the presence of these tissues in the otherwise dense structure are to be attributed the great amount of swelling which follows inflammation, and the enlargement of the tongue in the affection known as *macroglossia.*

The substance of the tongue is composed of intrinsic muscular fibres, with a small quantity of adipose tissue, arranged in symmetrical halves which are distinctly separated from each other by a *median fibrous septum.* This septum consists of a layer of fibrous tissue extending vertically from the base to the point, and sometimes contains a plate of fibro-cartilage. The intrinsic muscles of the tongue are the *linguales*, which consist of two strata of *longitudinal* fibres, the *superficial* and the *inferior*, the latter

being the larger, extending from the hyoid bone to the tip of the organ, and having between them an interlacement of *transverse* and *vertical* fibres. The extrinsic muscles of the tongue are those which mainly produce its numerous and complicated movements. The *genio-hyo-glossi muscles* arise from the upper genial tubercles on the inner side of the symphysis of the jaw, and their fibres radiate in a fan-like manner to be inserted into the whole of the under surface of the tongue and the upper part of the body of the hyoid bone. The action of the genio-hyo-glossi muscles is manifold. Their anterior fibres retract the tongue; their posterior fibres raise its base and help to protrude the organ. In connection with the linguales they draw down the centre of the tongue from the tip toward the base, as in sucking. The *hyo-glossi* are flat quadrilateral muscles which arise from the body and the cornua of the hyoid bone and blend with the other muscular fibres on the sides of the tongue. The fibres from the body pass upward and backward and overlap those from the greater cornua, which pass obliquely forward. The *stylo-glossi* arise from the outer sides of the apices of the styloid processes and from the stylo-maxillary ligaments, and curve downward to the sides of the tongue, each dividing into two portions, one of which blends with the lingualis and the other with the hyo-glossus. The *palato-glossi* are described with the soft palate, with which they are more particularly associated.

The sublingual salivary gland (Plate 13, Fig. 2, No. 4) is about the size and shape of an almond, situated between the mucous membrane and the mylo-hyoid muscle, its front portion resting in a depression behind the symphysis of the jaw. It has about a dozen ducts,—the *ducts of Rivinus*,—which open upon the floor of the mouth, mostly by independent orifices, but one of them terminates in the submaxillary duct, and is called the *duct of Bartholin*.

The submaxillary salivary gland (Plate 13, Fig. 2, No. 6, and Plate 18, No. 20) is very irregular in shape, and about twice the size of the sublingual gland. It is covered externally by the skin and platysma muscle (Plate 18), and is in relation to the posterior border of the mylo-hyoid muscle, generally presenting a submaxillary lobe beneath that muscle, and a buccal lobe above it, which terminates in the *duct of*

Wharton, which is five centimetres, or about two inches, in length, and opens by a narrow orifice at the side of the frænum linguæ. The submaxillary gland is placed a little in front of the angle of the jaw, and upon its back part is tunnelled by the facial artery, which after leaving it passes up over the body of the jaw in front of the masseter muscle. Posteriorly the submaxillary and parotid glands are separated by the stylo-maxillary ligament, although they are often joined together.

The *genio-hyoid muscles* are very slender fleshy bands which arise from the inferior genial tubercles back of the symphysis of the jaw and are inserted into the body of the hyoid bone. They act as elevators of the hyoid bone. The *mylo-hyoid muscle* arises mainly from the mylo-hyoid ridge of the lower jaw, extending from the symphysis to the alveolus of the last molar tooth, and is attached to the body of the hyoid bone. It presents a tendinous raphé where the anterior fibres are attached, but frequently this raphé is absent and the fibres from the mylo-hyoid of one side become continuous with those of the other and thus establish a muscular partition or diaphragm to the mouth. This muscle is also an elevator of the hyoid bone, as in swallowing.

The hyoid bone is a horseshoe-shaped bone, unattached to the general skeleton, placed above the larynx, and serving to support the numerous muscles of the tongue. When the head is held erect it may be felt just below the lower border of the jaw, and four and a half centimetres, or an inch and three-quarters, behind the chin (Plate 1). It consists of a body and right and left greater and lesser cornua. The *body* is the central portion, has a vertical ridge in the middle anteriorly, and posteriorly has a smooth concave surface which is in relation to the epiglottis. The *greater cornua* extend backward and a little upward to about a line dropped from the angle of the lower jaw on each side, and have blunt cartilaginous ends. The *lesser cornua* on each side are about the size of a grain of corn, and are connected, by a little joint lined with synovial membrane, to the point of junction of the body and the greater cornua. The hyoid bone is suspended by the *stylo-hyoid ligaments,* which extend from the tips of the styloid processes of the temporal bones to the lesser cornua. The hyoid bone is an important landmark in the upper part of the neck.

The tongue is very vascular, receiving most of its blood from a special artery upon each side, called the *lingual,* which enters its base and divides within its substance into numerous branches. These branches anastomose with one another and with vessels from the facial and ascending pharyngeal artery, but there is no communication from side to side, owing to the median fibrous septum, except perhaps by minute branches at the apex. The *lingual artery* arises from the external carotid artery about the level of the hyoid bone, round the greater cornu of which it curves, after crossing the superior laryngeal nerve and the middle constrictor muscle of the pharynx. Thence it passes inward beneath the hyo-glossus muscle and the hypoglossal nerve, about the point where the intermediate tendon of the digastric muscle pierces the stylo-hyoid muscle and becomes looped by a fold of deep fascia to the hyoid bone. At the anterior margin of the hyo-glossus muscle the artery passes in a very tortuous course along the under surface of the tongue toward its apex, where it is known as the *ranine artery.* The tortuous condition of the lingual artery enables it to accommodate itself to the elongation and movements of the tongue. In its course it gives off, near the greater cornu of the hyoid bone, the little *supra-hyoid artery;* close to the lesser cornu the *dorsal artery,* which supplies the mucous membrane at the back of the tongue and the tonsil, and the soft palate; and, in relation to the genio-hyo-glossus muscle, the *sublingual artery,* which supplies the sublingual gland.

In consequence of its vascularity, the tongue is often the seat of nævoid growths, and the operation of *excision* of the organ for cancer is apt to be attended with excessive hemorrhage unless the lingual artery is secured early in the undertaking.

In order to *expose the lingual artery for ligation,* a curved incision snould be made over the great cornu of the hyoid bone, about two centimetres, or a finger's breadth, from the angle of the jaw, and parallel with it, the head being turned back and to the opposite side. Upon reaching the tendons of the stylo-hyoid and the posterior portion of the digastric muscles, a layer of fascia is met with overlying the hypoglossal nerve, which can be seen through it taking a curved course parallel to the angle of the jaw. The artery is generally found under the nerve in this

relation, but if it originates higher up, in common with the facial artery from the external carotid, as it sometimes does, it can be readily found by drawing outward the submaxillary gland. The *lingual veins* accompany the branches of the lingual artery, forming net-works about them, but instead of emptying into a common trunk they join the superficial and the deep facial veins. The *ranine veins* are very large and tortuous, and are easily noticeable when the tip of the tongue is protruded and turned upward.

The *motor nerve* to the tongue is the *hypoglossal*, which leaves the skull by the anterior condyloid foramen, and, in close connection with the pneumogastric nerve, passes deeply beneath the internal jugular vein and the internal carotid artery, until it reaches a point corresponding to the angle of the jaw, when it comes forward between the vein and the artery, and, in relation to the posterior portion of the digastric muscle, takes a curved course over the carotid arteries and the occipital and facial arteries. As it crosses the occipital artery the branch called the *descendens hypoglossi* is given off, which lies for some distance upon the sheath of the carotid vessels and is distributed to the depressor muscles of the hyoid bone (Plate 21, No. 41). The hyo-glossus muscle separates the hypoglossal nerve from the lingual artery, along the upper border of the greater cornu of the hyoid bone. After passing over the hyo-glossus muscle the hypoglossal nerve communicates with the lingual nerve, and then penetrates the mylo-hyoid muscle and divides into various branches to supply all the lingual muscles with motor power. The hypoglossal nerve receives communications from the first two cervical nerves, and is also connected with the pneumogastric nerve and the superior cervical sympathetic ganglion at the base of the skull. These communications have important physiological bearings. The tongue receives its *sensory and gustatory functions* through the distribution of the lingual and glosso-pharyngeal nerves. The *lingual nerve* is a branch of the inferior maxillary nerve, and, descending between the internal pterygoid muscle and the ramus of the lower jaw (page 143), curves forward over the superior constrictor muscle of the pharynx and the upper part of the hyo-glossus muscle. In front of the latter muscle it is superficial to the duct of the submaxillary gland.

PLATE 24.

Figure 1.

The anterior region of the neck. The sterno-thyroid and sterno-hyoid muscles are removed to show the thyroid body in position. (Same as Plate 23.)

1. The right facial artery and vein.
2. The right digastric muscle.
3. The facial artery passing out of the submaxillary gland.
4. The thyroid notch.
5. The right thyro-hyoid muscle.
6. The right internal jugular vein.
7. The right superior laryngeal nerve.
8. The right superior thyroid artery and vein.
9. The right common carotid artery.
10. The right sterno-mastoid muscle.
11. The right omo-hyoid muscle.
12. The branches of the superior thyroid vessels over the right lobe of the thyroid body.
13. The anterior jugular vein, at the point where it passes over the isthmus of the thyroid body.
14. The right clavicular nerve.
15. The right external jugular vein.
16. The left facial artery and vein.
17. The left digastric muscle.
18. The left submaxillary gland.
19. The thyro-hyoid membrane.
20. The left internal carotid artery.
21. The left external carotid artery.
22. The left internal jugular vein.
23. The left thyro-hyoid muscle.
24. The left superior laryngeal nerve.
25. The left superior thyroid artery and vein.
26. The left sterno-mastoid muscle.
27. The left omo-hyoid muscle.
28. The left external jugular vein.
29. The superior thyroid vessels over the left lobe of the thyroid body.
30. The left clavicular nerve.

Figure 2.

The anterior region of the neck. The isthmus of the thyroid body is divided and the two lobes drawn to either side to expose the depth of the trachea at the root of the neck, and its relation to the deep transverse thyroid veins. (Same as Plate 23.)

1. The right facial artery and veins.
2. The right digastric muscle.
3. The right facial artery passing out of the submaxillary gland.
4. The right hyoid artery.
5. The body of the hyoid bone.
6. The thyroid notch.
7. The right thyro-hyoid muscle.
8. The right superior laryngeal nerve.
9. The right superior thyroid artery and veins.
10. The right common carotid artery.
11. The right internal jugular vein.
12. The right omo-hyoid muscle.
13. The right sterno-mastoid muscle.
14. The right lobe of the thyroid body, drawn aside.
15. The superficial cervical veins.
16. The right external jugular vein.
17. The right inferior thyroid artery and vein.
18. The right recurrent laryngeal nerve.
19. The transverse thyroid veins in the supra-sternal notch.
20. The manubrium sterni.
21. The left facial artery and vein.
22. The left digastric muscle.
23. The left submaxillary gland.
24. The left hyoid artery.
25. The thyro-hyoid membrane.
26. The left thyro-hyoid muscle.
27. The left internal carotid artery.
28. The left superior laryngeal nerve.
29. The left superior thyroid artery and vein.
30. The crico-thyroid artery over the crico-thyroid membrane.
31. The cricoid cartilage.
32. The left internal jugular vein.
33. The left omo-hyoid muscle crossing over the common carotid artery.
34. The left lobe of the thyroid body, drawn aside.
35. The left sterno-mastoid muscle.
36. The left external jugular vein.
37. The trachea.
38. The left recurrent laryngeal nerve.
39. The left clavicular nerve.
40. The supra-sternal notch.

N. B.—The dissections represented in Plates 23 and 24 were made upon a thick, short-necked, well-developed male subject, aged thirty-five years, to demonstrate the parts especially concerned in the operations of laryngotomy and tracheotomy.

Plate 24

Vol I

Fig 1

Fig 2

At the under surface of the tongue the lingual nerve divides into numerous branches (Plate 13, Fig. 2, No. 1), which ultimately are distributed to the mucous membrane and the fungiform and filiform papillæ on the anterior three-fourths of the dorsum of the organ. It also supplies the neighboring mucous membrane of the mouth and gums and the lingual gland, and connects with the terminal branches of the hypoglossal nerve at the apex of the tongue. In severe neuralgic affections of the tongue division of this nerve sometimes affords relief. It can readily be reached by making an incision through the mucous membrane between the vertical ramus of the jaw and the last molar tooth, or, if the mouth is too small, by an external incision through the cheek in the line of the oral commissure. In relation to the external pterygoid muscle the lingual nerve is joined by the chorda tympani from the facial nerve, as already described (page 143); and it sends a few filaments to the submaxillary ganglion near the posterior border of the mylo-hyoid muscle.

The submaxillary ganglion is not larger than a pin's head, and is situated on the hyo-glossus muscle behind the point where the lingual nerve crosses the submaxillary duct. Its *motor* root is the chorda tympani; its *sensory* roots come from the lingual, and its *sympathetic* root is formed by a branch from the sympathetic plexus around the facial artery. The branches of distribution go to the submaxillary gland, to the floor of the mouth, and sometimes to the hypoglossal nerve. The *glosso-pharyngeal nerve* leaves the skull at the middle of the jugular foramen anterior to the pneumogastric and spinal accessory nerves, and passes between the internal jugular vein and the internal carotid artery, crossing the latter vessel below the styloid process to curve forward over the stylo-pharyngeus muscle. Here it holds an intermediary position between the lingual and hypoglossal nerves (Plate 13, Fig. 2, No. 16, and Plate 36, No. 7), and divides into branches which supply the mucous membrane of the pharynx, the tonsil, and the back of the tongue. There are two branches of the glosso-pharyngeal nerve which supply the back portion of the tongue. One is distributed to the circumvallate papillæ and the surface between them and the epiglottis; the other passes along the side of the tongue and joins with the lingual nerve.

The tongue is plentifully supplied with *lymphatic vessels*, which mostly accompany the ranine vessels, and, after entering several small lymphatic glands upon the hyo-glossus muscle, terminate in the deep cervical glands.

The space between the cavity of the mouth and that of the pharynx is called the *fauces*, and the narrow part of this space bounded by the palatine arches constitutes the *isthmus faucium.* Within the triangular intervals between the anterior and posterior pillars of the palate, on each side, are situated the tonsils.

The tonsils (*amygdalæ*) (Plate 13, Fig. 2, No. 15, Fig. 3, No. 16) are two oval glandular bodies, composed of an aggregation of lymphatic follicles, between which small mucous glands open, and are covered on the external surface by a fibrous sheath and an expansion of the submucous lining of the pharynx. Normally they should not project beyond the palato-glossal folds; and their inner surfaces are marked with minute depressions, which are the orifices leading into the glandular crypts or follicles. The secretion of the tonsils, in the healthy state, is viscid and transparent; but it is apt to become white and thick from inflammation, as in chronic tonsillitis, and to accumulate in the superficial depressions, appearing like small ulcers or detached pieces of membrane. The tonsils are variably enlarged in different individuals, and their removal is so often required that their immediate relations are of great interest. The enlargement, however, is generally toward the middle of the throat, where no resistance is offered; and it is for this reason not so easy as it is often supposed to be to feel an hypertrophied tonsil through the external surface of the neck, where it is in relation to the angle of the jaw. There are several lymphatic glands between the tonsils and the greater cornua of the hyoid bone, which receive the lymphatic vessels from the tonsils: these are usually enlarged when the tonsils are indurated, and their enlargement may easily be mistaken for the tonsils themselves. Each tonsil is separated by the superior constrictor muscle of the pharynx and its aponeurosis from the internal carotid artery and the ascending pharyngeal branch of the external carotid. The latter is very close to the tonsil, but the internal carotid, except when it is very tortuous, is really out of the way from danger of being wounded in excision of the tonsil or in the opening of a

tonsillitic abscess. The external carotid artery is not far from the outer surface of the tonsil, and the *facial artery* is almost always in close connection with its front border, where it furnishes the *tonsillar branch*, which is the vessel most apt to give rise to troublesome hemorrhage. The tonsil itself is very vascular, as it receives blood from many sources,—the tonsillar and palatine branches of the facial, the descending palatine from the internal maxillary, the ascending pharyngeal, and the dorsalis linguæ all contributing to it.

The *veins* from the tonsil form the *tonsillar plexus* on the outer side of the gland, which empties into the inferior palatine vein and thence into the deep facial vein. The *nerves* to the tonsil are derived from Meckel's ganglion and from the glosso-pharyngeal nerve. There is a continuous chain of lymph-follicles extending from one tonsil to the other across the upper part of the pharynx. The lymphatics arise around the numerous follicles in the glandular substance and pass into the submaxillary lymphatic glands.

The pharynx (Plates 12 and 13) is the passage-way which connects the cavity of the mouth with the œsophagus. It is eleven centimetres, or about four and a half inches, in length, and extends from the base of the skull to the level of the cricoid cartilage. It is lined with a mucous coat continuous with that of the neighboring passages which open into it, and its walls consist of muscular fibres arranged in three overlapping planes, and of a fibrous layer, called the *pharyngeal aponeurosis*, which is interposed between the muscular and mucous coats. The widest part of the pharynx is at the level of the greater cornua of the hyoid bone, where it measures five centimetres, or two inches, across; its narrowest part is at its junction with the œsophagus, it being here only about nineteen millimetres, or three-quarters of an inch, in diameter, and it is here, consequently, that foreign bodies most frequently become lodged. Owing to the yielding nature of the walls of the pharynx, its cavity is very dilatable. The submucous tissue of the pharyngeal aponeurosis is much thicker above, where the muscles are deficient, than it is below, where it gradually becomes lost as the tube becomes contracted. It is attached to the basilar process of the occipital bone and to the apices of the petrous portions of

the temporal bones. In the middle the aponeurosis is strongly fixed to the pharyngeal spine of the occipital bone, and it is continued downward as the posterior raphé into which the constrictor muscles are inserted. The *superior constrictor muscle* is practically a continuation backward of the buccinator muscle (page 121), being separated from it only by the pterygo-maxillary ligament. Its fibres are pale in color, and they arise from the hamular process and the lower part of the internal pterygoid plate of the sphenoid bone, from the tuberosity of the palate bone, and from the posterior portion of the mylo-hyoid ridge on the lower jaw, to be inserted mainly into the upper part of the posterior raphé. The upper border of the superior constrictor is attached by a few fibres to the pharyngeal spine, and then arches beneath the levator palati muscle and the Eustachian tube, leaving a semilunar space below the base of the skull, known as the *sinus of Morgagni.* The deficiency in muscular fibres in this space is made up for by a thickening of the aponeurosis in this locality. The superior constrictor, in addition to the above, also takes origin from the pterygo-maxillary ligament and from the reflected tendon of the tensor palati muscle. The lower border is overlapped by the *middle constrictor.* The latter muscle arises from the upper border of the greater and lesser cornua of the hyoid bone and part of the stylo-hyoid ligament. Its fibres diverge in a radiating manner to their insertion at the median raphé, where the middle ones interlace with those of the opposite muscle. The middle constrictor is partially separated from the superior by the *stylo-pharyngeus muscle,* a long slender fasciculus which arises from the inner side of the base of the styloid process and is mainly inserted into the posterior border of the thyroid cartilage, a few of its fibres blending with those of the constrictors. The lower border of the middle constrictor is overlapped by the inferior constrictor. The lingual artery runs forward between the outer surface of the middle constrictor and the hyo-glossus muscle.

The *inferior constrictor muscle* is the thickest of the three, and arises from the side of the cricoid cartilage, behind the crico-thyroid muscle, and from the oblique line on the great wing of the thyroid cartilage and to its lower cornu. The fibres spread out from their origin and are

inserted into the posterior raphé. The lower fibres blend with the circular fibres of the œsophagus. Between the middle and inferior constrictor muscles the superior laryngeal artery and nerve penetrate the thyro-hyoid membrane to supply the larynx, and beneath the lower border of the inferior constrictor muscle the recurrent laryngeal nerve enters the larynx. The action of the constrictor muscles is to compress the pharynx from above downward. The cavity of the pharynx is divided anteriorly by the plane of the soft palate into an upper portion, the *naso-pharynx*, and a lower, the *oro-pharynx*. The mucous membrane varies in these different parts, and is peculiarly adapted to their purposes: the former, being for the passage of air, is lined with columnar ciliated epithelium and very delicate, and the latter, for the passage of food, is provided with squamous epithelium like the rest of the mouth. Throughout the whole of the pharynx there are numerous mucous glands whose secretion keeps the surface lubricated. In the neighborhood of the Eustachian tubes there are aggregations of these mucous glands and lymphatic follicles, constituting the so-called *pharyngeal tonsils*. This area is peculiarly liable to become thickened and swollen in catarrh. The mucous membrane on each side of the upper part of the pharynx is puckered into a pouch, called the *pharyngeal recess*.

The Eustachian tube, which conveys the air to the cavity of the tympanum (page 65), on each side, opens, by a perpendicular elliptical slit twelve millimetres, or about half an inch, in length, opposite the back part of the inferior turbinated bone, in the naso-pharynx (Plate 12, No. 32). The tube has the tensor palati muscle to the outer side and in front of it, and the levator palati muscle internal and behind it. Its orifice is usually closed, but during swallowing the tensor palati probably serves to open it. There is a slight bulging of the mucous membrane behind the opening of the Eustachian tube, formed by the levator palati. In relation to the glottis the mucous membrane is gathered into folds, which allow of the expansion of this part of the pharynx in deglutition. The mucous membrane of the pharynx is readily inflamed, owing to its great vascularity, and the inflammatory process is apt to involve the larynx through contiguity of structure. The pharynx is separated posteriorly

PLATE 25.

Figure 1.

Deep dissection of the root of the neck. The thyroid body and omo-hyoid muscle are hooked aside to show the vessels and nerves, and the clavicle is detached from the sternum.

1. The anterior portion of the right digastric muscle.
2. The facial artery and vein, coursing along the front border of the masseter muscle.
3. The masseter muscle.
4. The tendon of the digastric muscle, looped down to the hyoid bone by a band of the deep cervical fascia.
5. A cluster of superficial lymphatic glands.
6. The omo-hyoid muscle, drawn aside.
7. The descendens hypoglossi nerve, over the common carotid artery.
8. The sterno-mastoid muscle, turned back.
9. The internal jugular vein.
10. The scalenus anticus muscle, separating the subclavian artery and vein.
11. The inferior thyroid artery.
12. The common carotid artery.
13. The cords of the brachial plexus of nerves.
14. The subclavian artery.
15. The vagus (or pneumogastric nerve).
16. The subclavian vein.
17. The right innominate vein.
18. The innominate artery.
19. The subclavius muscle.
20. The clavicle, detached from the sternum and pulled forward.
21. The anterior portion of the left digastric muscle.
22. The body of the hyoid bone.
23. The thyro-hyoid membrane.
24. The thyroid notch.
25. The crico-thyroid muscle.
26. The superior thyroid artery and vein.
27. The superior laryngeal nerve.
28. The left sterno-mastoid muscle.
29. The cricoid cartilage.
30. The thyroid body.
31. The isthmus of the thyroid body.

Figure 2.

Deep dissection of the root of the neck. (Same as Figure 1, the veins being removed.)

1. The facial artery.
2. The posterior portion of the digastric muscle.
3. The external carotid artery.
4. The internal carotid artery.
5. The bifurcation of the common carotid artery.
6. The sterno-mastoid muscle, turned back.
7. The omo-hyoid muscle, drawn aside,
8. The outer cord of the brachial plexus.
9. The middle cord of the brachial plexus.
10. The inner cord of the brachial plexus.
11. The subclavian artery.
12. The clavicle.
13. The superior thoracic branch of the axillary artery.
14. The anterior portion of the digastric muscle.
15. The body of the hyoid bone.
16. The lingual artery and hypoglossal nerve.
17. The thyroid notch.
18. The crico-thyroid muscle.
19. The superior thyroid artery.
20. The superior laryngeal nerve.
21. The left sterno-mastoid muscle.
22. The cricoid cartilage.
23. The common carotid artery.
24. The left lobe of the thyroid body.
25. The inferior thyroid artery.
26. The trachea.
27. The scalenus anticus muscle.
28. The pneumogastric nerve.
29. The innominate artery.
30. The phrenic nerve.
31. The manubrium sterni.
32. The first external intercostal muscle.

Fig 1


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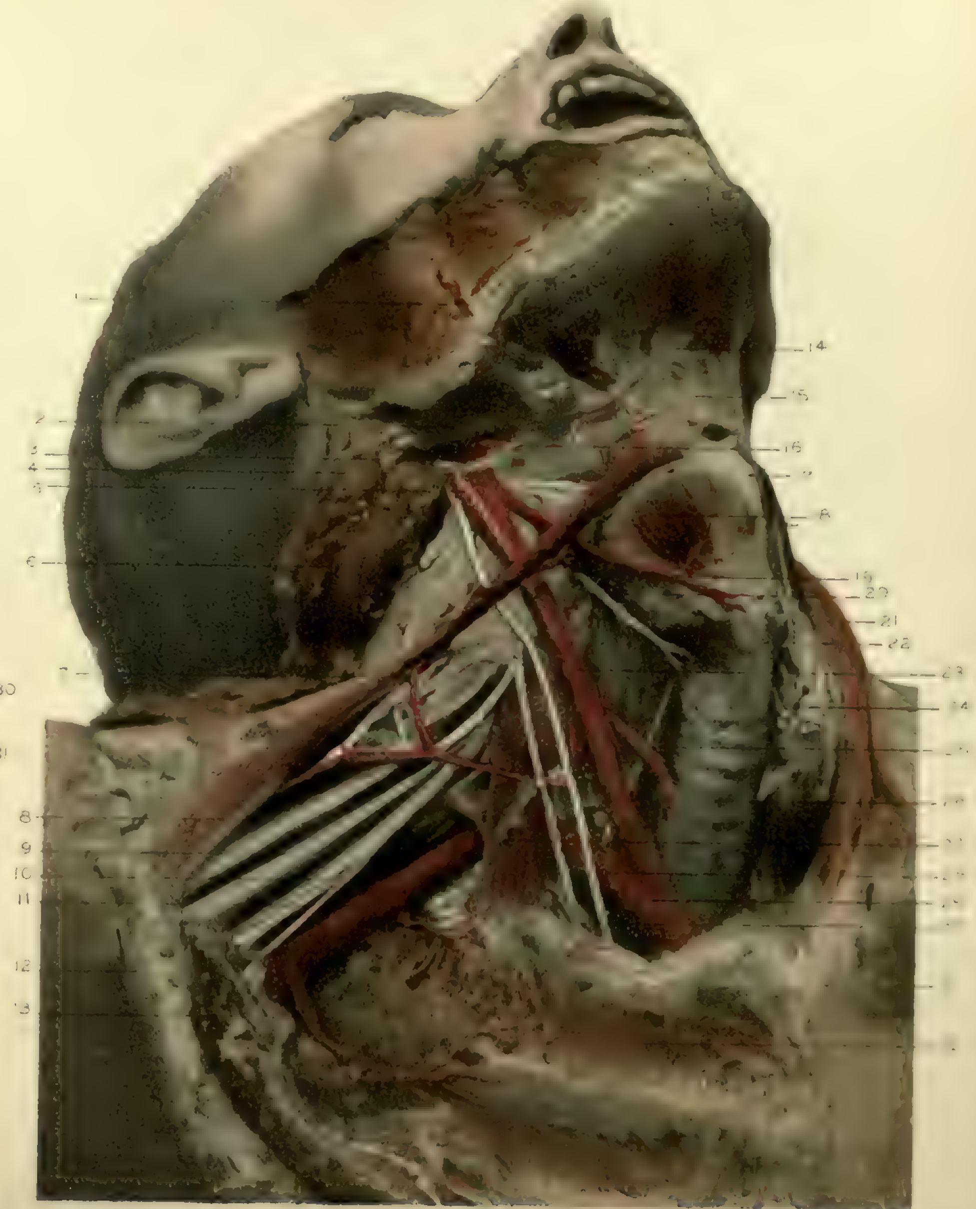
Fig 2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from the prevertebral muscles and their fascia by the loose but strong *post-pharyngeal fascia*, which is connected with the sheaths of the carotid vessels on each side (Plate 13), and which has an extension outward by the gap in the deep cervical fascia by which the pharyngeal wall is brought into relation with the parotid region, as in post-pharyngeal abscess (page 133). In the connective tissue between the back of the pharynx and the axis vertebra there is a little lymphatic gland, which sometimes is the seat of a suppurative collection.

In the areolar layer between the pharyngeal fascia and the constrictor muscles is the *pharyngeal plexus of veins*, made up of numerous intercommunicating veins which branch in all directions and terminate in the internal jugular veins.

The structures of the pharynx receive their arterial blood by branches from the ascending palatine and ascending pharyngeal arteries. The lateral walls of the pharynx are in close proximity, on each side, to the internal carotid artery and to the pneumogastric, glosso-pharyngeal, and hypoglossal nerves (Plate 13, Figs. 2 and 3).

The constrictor muscles are all supplied with nerves from the pharyngeal plexus of nerves, the inferior constrictor receiving in addition twigs from the external and recurrent laryngeal nerves. The lymphatic vessels of the pharynx empty into the deep cervical lymphatic glands, which form a chain along the sheath of the carotid artery and internal jugular vein.

THE REGION OF THE LARYNX.

At the back of the tongue, and behind the stretch of mucous membrane which contains the chain of follicles extending between the tonsils, is the pharyngeal opening of the larynx. It is a triangular aperture, having its base directed toward the tongue, and the **cavity of the larynx** into which it leads extends as far as the lower border of the cricoid cartilage.

The larynx is the commencement of the respiratory passage, and serves as the organ of the voice, in which are produced the sonorous vibrations caused by the air coming from the lungs, bronchial tubes,

and trachea. It is triangular and broad above, narrow and cylindrical below, and flattened behind and at the sides. It consists of a cartilaginous framework, composed of nine separate pieces, which are united by ligaments and moved by numerous muscles; and its cavity is lined with mucous membrane continuous with that of the pharynx, mouth, and nose above, and with that of the trachea below, but peculiarly modified in this region to subserve the function of phonation. The pharynx, mouth, and nose form the auxiliary apparatus which modifies the sound after it passes from the larynx, adapting it to articulation. **The thyroid cartilage** is the largest cartilage of the larynx, and consists of two lateral quadrilateral portions, the *alæ*, which are united anteriorly at an acute angle, so that they form a vertical median projection. This projection is called the *pomum Adami* (Plate 1, and Plate 53, Fig. 1), and is subcutaneous, being more marked in the male than in the female, and always serving as an important landmark in the front of the neck. It is usually separated from the skin by a bursa mucosa; and there is a *median notch* at the upper part of the projection, the *thyroid notch* (Plates 23, 24, and 25), which allows the cartilage to glide behind the overlying hyoid bone in the act of swallowing. This is accomplished by the mode of attachment of the broad, fibro-elastic, *thyro-hyoid membrane*, which extends from the upper border of the thyroid cartilage to the posterior and upper border of the hyoid bone, a little synovial bursa being interposed between the membrane and the bone. The posterior border of each ala of the thyroid cartilage is free and prolonged upward into a blunt cylindrical process, the *superior cornu*, which is connected to the corresponding greater cornua of the hyoid bone by a *posterior thyro-hyoid ligament*, and downward into a shorter process, the *inferior cornu*, which curves forward and articulates with the outer side of the cricoid cartilage. Both the superior and inferior borders of the alæ are notched in front of their respective cornua and present convexly everted lips as they approach each other at the middle line in front. The inferior border affords attachment to the crico-thyroid membrane which connects the thyroid and cricoid cartilages. The outer surface of each ala is smooth and marked by a faint oblique line, which extends from the base of the superior cornu down-

ward and forward and gives attachment to the sterno-thyroid and thyro-hyoid muscles. The inferior constrictor muscle of the pharynx is also attached to the surface behind the oblique line. The inner surface of each ala is slightly concave, smooth, and covered by mucous membrane. The thyroid cartilage is so called from its resemblance to a shield, and because it protects the important structures behind it.

The *cricoid cartilage* very closely resembles a signet-ring (hence its name), and is situated below the thyroid cartilage, with the hoop of the ring forward and in close contact with the top ring of the trachea. The posterior, broad, seal-like portion of the cricoid cartilage is two and a half centimetres, or an inch, in depth, and is received into the interval between the posterior borders of the alæ of the thyroid cartilage. The narrow hoop-like portion of the cricoid cartilage can readily be felt subcutaneously, being prominent in lean and in fat persons at all periods of life, and is therefore always a reliable landmark in the anterior region of the neck. The surface of the upper border of the cricoid cartilage is directed obliquely upward and backward, and gives attachment to the crico-thyroid membrane, which is thicker in front than at the sides and is composed mainly of yellow elastic tissue. Outwardly on each side there is an elevated facet, which articulates with the inferior cornu of the thyroid cartilage, and, being provided with a synovial membrane and a capsular ligament, forms a distinct joint which allows of a revolving motion between the two cartilages. On the upper border of the broad posterior portion there are also two oval convex surfaces for articulation with the bases of the arytenoid cartilages, the intervening cavity being occupied by the arytænoideus proprius muscle. The *arytenoid cartilages* are so called because when approximated by the action of the latter muscle they resemble the mouth of a pitcher. They are pyramidal in form, and play an important part in the mechanism of the larynx. These cartilages are symmetrically placed upon the upper and back surface of the cricoid cartilage, and therefore occupy the upper part of the interval between the posterior borders of the alæ of the thyroid cartilage. Their apices are directed backward and inward, while their anterior and posterior surfaces are respectively convex and concave. Their inner surfaces are

nearly flat, and face each other, being covered by the lining mucous membrane. The posterior surfaces afford attachment to the *arytænoideus muscle.* The anterior surfaces are irregular, and afford attachment to the thyro-arytænoideus muscle on each side and to the fold of mucous membrane called the upper or *false* vocal cord. Where the anterior surface rests upon the cricoid cartilage there is a pointed angle (the vocal process), to which is attached the *true* vocal cord. Each apex is surmounted by a nodule, the *corniculum laryngis* (*of Santorini*), which serves to continue the arytenoid cartilage upward and inward.

The epiglottis is a thin, oval, leaf-shaped plate of fibro-cartilage, the free rounded margin of which can usually be seen through the mouth when the tongue is protruded (Plate 13, Fig. 4, No. 17), and serves as a trap-door to close the glottis against the intrusion of food in deglutition. Its lower end is long and narrow, and connected by the *thyro-epiglottic ligament* to the angle of the thyroid cartilage just below the median notch between the two alæ and above the vocal cords. A fibrous connection also exists between it and the posterior surface of the hyoid bone,—the *hyo-epiglottic ligament.* The mucous membrane is extended from the base and sides of the tongue upon the anterior surface of the epiglottis in three folds, constituting the median, right, and left *glosso-epiglottic ligaments.* The posterior surface is covered with a number of little mucous glands lodged in depressions, and its mucous membrane is reflected upon each side, in loose folds, to the arytenoid cartilage, forming the *aryteno-epiglottic folds.* The function of the mucous glands is to keep the adjoining parts moist: they are peculiarly apt to become inflamed in those who speak much in public, and are the seat of "clergyman's sore throat." The laxity of the aryteno-epiglottic folds is due to the quantity of areolar tissue in their locality, which allows of considerable swelling in acute laryngitis, and becomes the seat of the dangerous condition known as "œdema of the glottis." Foreign bodies of considerable size also often become retained for long periods of time within these folds of the mucous membrane. Within the aryteno-epiglottic folds there are small whitish nodules of cartilage, one on each side, in immediate relation to the apex of the arytenoid cartilage, and known as the *cuneiform* (or *Wrisberg's*) *cartilages.*

Occasionally there are found minute accessory cartilaginous plates situated near the anterior borders of the vocal cords in the female larynx, to which has been attributed the power of the singing voice in the so-called "head-notes" (Seiler). The principal cartilages of the larynx, the thyroid, the cricoid, and the arytenoid, are of the hyaline variety, and have a tendency to ossify in old age; but the epiglottis, the cornicula, and the cuneiform cartilages do not change, being composed of yellow fibro-elastic tissue. Between the cartilaginous framework and the mucous lining there is a layer of elastic connective tissue, called the *laryngeal fascia.*

To one looking down into the cavity of the larynx the mucous membrane presents, in the middle line, below the epiglottis, an elevation known as the *cushion*, or *pulvinar*, of the epiglottis, from which a crescentic fold arches downward on each side enclosing some fatty tissue and ligamentous fibres, the *superior thyro-arytenoid ligaments*, or *false vocal cords.* Below these there is another pair of more prominent folds, which extend on each side from the anterior angles of the bases of the arytenoid cartilages to the sides of the middle thyroid fossa. These are composed of fibro-elastic tissue, the *inferior thyro-arytenoid ligaments*, or *true vocal cords*, and are covered with a very thin and closely-adherent layer of mucous membrane, through which their free inner margins appear as white glistening bands. The spaces between these upper and lower projections on each side are called the *ventricles of the larynx*, which are recesses opening into a small pouch, the *sacculus laryngis* (*of Morgagni*), and allow freedom to the vibrations of the true vocal cords. Each sacculus ascends between the upper fold and false vocal cord and the inner surface of the thyroid cartilage nearly to its upper border and at the side of the epiglottis. It contains a number of follicular glands, whose secretion lubricates the true vocal cords through the action of the so-called *compressor sacculi laryngis* muscle. The strength and depth of sound are probably due to the development of the ventricles.

The opening in the cavity of the larynx between the inferior or true vocal cords is the **glottis.** It is of triangular form, with the apex forward when the parts are at rest, but varies in shape, and becomes contracted or dilated, according as the vocal cords are rendered tense or relaxed by

muscular action. The glottis begins in a point at the back of the thyroid cartilage, and is bounded on each side by the inner edges of the true vocal cords and by the interval between the arytenoid cartilages. It is limited behind by the mucous membrane reflected over the arytænoideus muscle. The anterior portion of the opening, between the vocal cords, is called the *vocal area,* and the posterior portion, between the arytenoid cartilages, the *respiratory area.* The length of the glottis varies in the male and the female, being, after puberty, in the former a little less than two and a half centimetres, or an inch, and in the latter about two centimetres, or three-quarters of an inch. The width depends upon the degree of dilatation or contraction of the vocal cords. When they are at rest the widest part does not exceed four or five lines in the male and two or three lines in the female: hence the name *rima glottidis,* or chink of the glottis. In speaking or singing the glottis is narrowed and the vocal cords are nearly parallel. Below the true vocal cords the cavity of the larynx widens, becoming nearly circular at the lower margin of the cricoid cartilage. The vocal cords measure in the adult male a little over twelve millimetres, or half an inch, and in the female a little less. At puberty they undergo marked modification with the development of the rest of the vocal apparatus.

The *intrinsic muscles,* which act upon the larynx and are especially concerned in producing changes in the vocal cords by which they modify the voice, are arranged in four pairs,—the crico-thyroid, the thyro-arytenoid, the posterior and lateral crico-arytenoid, on each side, and a single one in the middle, the arytænoideus proprius muscle. The *crico-thyroid muscles* (Plates 23, 24, and 25) arise from the front and sides of the cricoid cartilage and pass obliquely to be inserted into the inferior border and cornu of the thyroid cartilage on each side. Acting from above, these muscles raise the hoop of the cricoid cartilage, and thereby depress the arytenoid cartilages so as to stretch and render tense the true vocal cords, the thyroid cartilage being at the same time fixed by the extrinsic thyro-hyoid muscles (page 236).

The crico-thyroid muscles receive their motor influence from the external branch of the superior laryngeal nerve, being the only muscles

of the larynx supplied by that nerve, while the rest of its branches, being sensory, are distributed to the mucous lining membrane of the organ. There are connecting filaments, however, between the superior laryngeal nerve and the inferior or recurrent laryngeal nerve, which furnishes all the other intrinsic laryngeal muscles with motion.

The *thyro-arytenoid muscles* each consist of two flat overlapping portions. The *outer* portions arise from the thyroid alæ and the contiguous portion of the crico-thyroid membrane, and pass backward to be inserted by some transverse fibres into the arytenoid cartilages, and by some oblique fibres into the aryteno-epiglottic folds, a few of the latter fibres passing to the epiglottis on each side and being therefore sometimes called the *thyro-epiglottic muscles.* The *inner* portions arise from the anterior attachment of the true vocal cords and the adjacent fossa of the thyroid cartilage, and, passing backward, are inserted into the anterior angles of the bases of the arytenoid cartilages. Their fibres run parallel with the true vocal cords, many of them blending with the thyro-arytenoid ligaments in their substance, the vocal fibres and others radiating beneath the mucous membrane over the ventricles of the larynx. Owing to the diversity of origin of their fibres, the thyro-arytenoid muscles are very complicated in their action. Their main use is to draw forward the arytenoid cartilages and thus to relax the vocal cords; but, owing to the connection of their inner portions with the cords, the degree of tension of the latter is supposed to be modified by the independent action of the vocal fibres of the muscles. The successive action of the various fibres in unison on both sides produces a rotation of the arytenoid cartilages inward, so that the rima glottidis is narrowed and the vocal cords are approximated, assuming the position necessary for phonation.

The *posterior crico-arytenoid muscles* arise from the flattened surfaces on the cricoid cartilage on each side of the posterior median ridge. Their fibres are also arranged in segments, most of them converging to the outer angles of the bases of the arytenoid cartilages, but some of the lowest fibres often pass to be inserted into the inferior cornua of the thyroid cartilage. The action of these muscles is brought into play at each inspiration during life, and serves to rotate the arytenoid cartilages

PLATE 26.

Figure 1.

The sternum and costal cartilages removed to show the anterior mediastinum, and particularly the relations of the pleuræ to the pericardium.

1. The right pneumogastric nerve.
2. The right recurrent laryngeal nerve.
3. The innominate artery.
4. The right innominate vein.
5. The superior vena cava.
6. The costal surface of the right pleural sac.
7. The sternal end of the right fifth rib.
8. The right pleural sinus overlapping the pericardium.
9. The sternal end of the right sixth rib.
10. The upper surface of the diaphragm.
11. The left pneumogastric nerve.
12. The left scalenus anticus muscle.
13. The left subclavian artery.
14. The left subclavian vein.
15. The left innominate vein.
16. The left pleural sac.
17. The pericardium over the great vessels at the base of the heart.
18. The pericardium over the right ventricle of the heart.
19. The sternal end of the left fifth rib.

Figure 2.

Dissection of the vascular system of the fœtus (at five months and a half).

N. B.—The injection was introduced by the umbilical vein, and the photograph represents the actual size.

1. The right common carotid artery, pneumogastric nerve, and jugular vein.
2. The innominate artery.
3. The entrance of the superior vena cava into the right auricle of the heart.
4. The right lung in the back wall of the thoracic cavity.
5. The ductus venosus passing into the inferior vena cava.
6. The inferior vena cava.
7. The hepatic veins.
8. The portal vein.
9. The umbilical vein.
10. The umbilical cord.
11. The left common carotid artery and jugular vein.
12. The arch of the aorta, showing the origin of the great arteries.
13. The ductus arteriosus.
14. The left branch of the pulmonary artery.
15. The pulmonary artery.
16. The left lung in the back of the thoracic cavity.
17. The heart, with the right and left coronary vessels.
18. The diaphragm.
19. The abdominal aorta.
20. The left kidney.
21. The left renal vein.
22. The right hypogastric artery.
23. The bladder.
24. The left hypogastric artery.

Figure 3.

Dissection of a child, three weeks after birth, showing especially the relations of the thymus gland and the supra-renal capsules.

1. The crico-thyroid arteries.
2. The cricoid cartilage.
3. The thyroid body.
4. The right internal mammary artery and veins on the inner surface of the wall of the thorax, which is reflected outward.
5. The right innominate vein.
6. The thymus gland overlying the arch of the aorta and the left innominate vein.
7. The right lung.
8. The right auricle of the heart.
9. The right supra-renal capsule.
10. The right renal vein.
11. The right kidney.
12. The inferior vena cava.
13. The left common carotid artery and jugular vein.
14. The left internal mammary vessels on the inner surface of the thoracic wall, reflected outward.
15. The pulmonary artery.
16. The left lung.
17. The right ventricle of the heart.
18. The left supra-renal capsule.
19. The abdominal aorta.
20. The hilum of the left kidney.
21. The branches of the superior mesenteric artery.

Figure 4.

Photograph of a preparation (in the author's cabinet), showing a remarkable disposition of the heart and independent origins of all of the great vessels from the root of the aorta.

N. B.—This specimen was removed from the body of a young man, aged twenty-seven years, who died from phthisis. There is no arch to the aorta, and the position of the heart, when discovered, was vertical within the thorax, as shown in the figure. There is only one auricle and one ventricle. No other abnormality of the arteries was found in the body.

1. The right external carotid artery.
2. The right internal carotid artery.
3. The right superior thyroid artery.
4. The right common carotid artery.
5. The right thyroid axis.
6. The independent origin of the right subclavian artery.
7. The left external carotid artery, branching into the lingual, facial, and temporal arteries.
8. The left internal carotid artery.
9. The left superior thyroid artery.
10. The left common carotid artery.
11. The left vertebral artery.
12. The left transversalis colli and supra-scapular arteries.
13. The left subclavian artery.
14. The independent origin of the left subclavian artery.
15. The auricle of the heart.
16. The ventricle of the heart.
17. The descending aorta.

Plate 26


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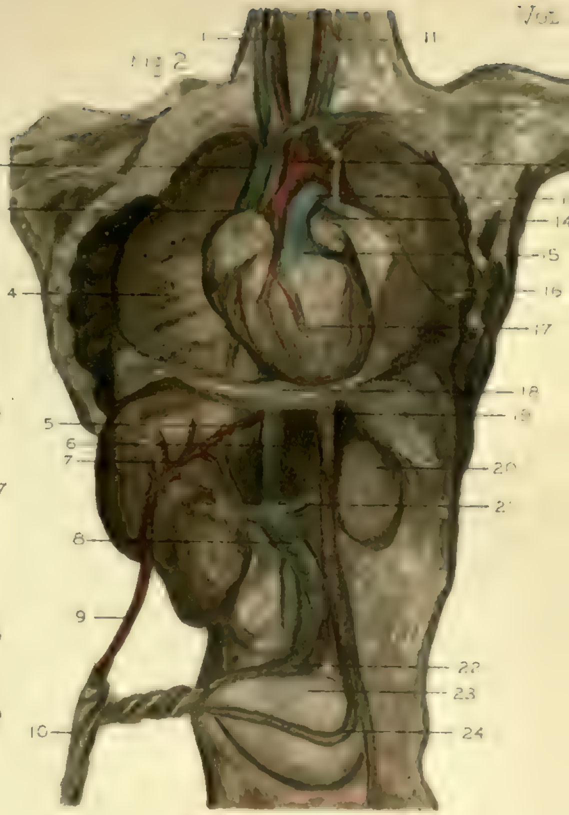
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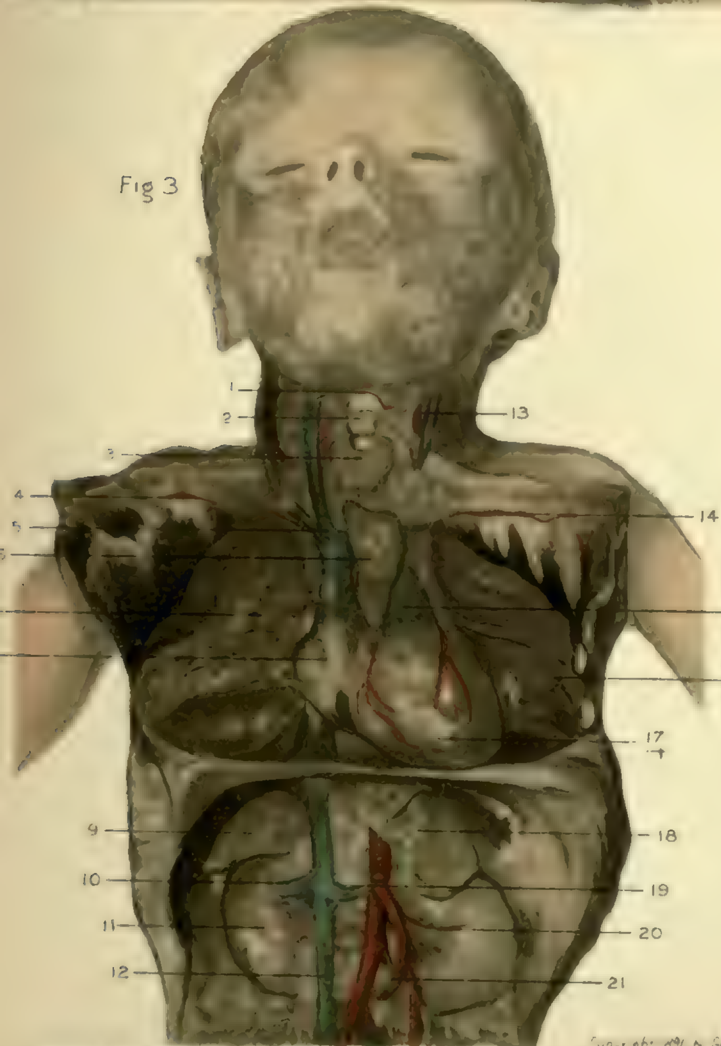
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Fig 4
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by drawing their outer angles toward the middle line, and consequently their anterior angles, to which the vocal cords are attached, from the middle line, so that the rima glottidis is dilated. The *lateral crico-arytenoid muscles* are much smaller than the posterior. They can be seen only by removing the alæ of the thyroid cartilage. They arise from the sides of the upper border of the cricoid cartilage, and are inserted by their converging fibres into the outer angles of the bases of the arytenoid cartilages in front of the posterior crico-arytenoid muscles. They serve to draw the arytenoid cartilages inward and forward, and thus to approximate and relax the vocal cords. The single *arytenoid muscle* is attached to the posterior surfaces of the arytenoid cartilages, and mainly consists of transverse fascicles, which serve to draw them together and thus cause the contraction of the rima glottidis. There are other muscular fibres, intimately connected with the former, which arise from the outer angles of the arytenoid cartilages and ascend obliquely from side to side, so that they cross one another, some to be attached to the apices of the opposite arytenoid cartilages, while others are continued within the aryteno-epiglottic folds to the sides of the epiglottis and are therefore sometimes called the *aryteno-epiglottic muscles.* The lower fasciculi of the latter constitute the *compressor sacculi muscles* (*of Hilton*), already referred to. Throughout the folds of the mucous membrane in relation to the epiglottis there are other bundles of muscular fibres, sometimes more developed than at other times, the functions of which have given rise to much speculation; but they are of little comparative importance, having probably nothing to do with the modification of the voice, but rather assisting the constricting influences upon the epiglottis in swallowing. At puberty these muscles are not so rapidly developed as the cartilages, and it is owing to this that the so-called "change of voice" occurs. These muscles become stronger with practice, according to the efforts of singers and speakers.

The *extrinsic muscles of the larynx* are those which are attached to the hyoid bone and thyroid cartilage, which they serve to fix so that the intrinsic muscles can act. They are described with the anterior region of the neck.

The *arteries of the larynx* are derived from the superior or descending thyroid branch of the external carotid artery and the inferior or ascending thyroid branch from the thyroid axis of the subclavian artery. The superior thyroid furnishes most of the blood-supply to the larynx by means of the *superior laryngeal artery*, which runs inward beneath the extrinsic laryngeal muscles, and, after passing between the middle and inferior pharyngeal constrictor muscles (page 173), penetrates the thyro-hyoid membrane and sends branches to the intrinsic muscles and mucous membrane. Sometimes this vessel perforates the ala of the thyroid cartilage. Its radicles anastomose freely with those of its fellow and with those from the inferior thyroid arteries, so that the mucous membrane is very vascular, as is demonstrated by the rapid engorgement and change from the ordinary pink color to a bright red in consequence of the slightest irritation. The external continuation of the superior laryngeal artery descends to the inferior border of the thyroid cartilage, close to which it courses over the crico-thyroid membrane and is here called the *crico-thyroid artery* (Plates 20, 23, 24, and 25). This vessel forms a little communicating loop with its fellow from the opposite side, which ordinarily is very insignificant, and, as the loop itself is nearer to the thyroid cartilage than the cricoid, it can be avoided in an emergency operation for laryngotomy by introducing the knife with the blade parallel to and just above the upper border of the cricoid cartilage and then turning the cutting edge downward toward the middle line. Occasionally, however, the crico-thyroid artery is quite large (Plate 24, Fig. 2, No. 30), or there may be present an anomalous branch from the superior thyroid artery (Plate 25), occupying its position: so that, if time permits, it is safer not to open the larynx without making a preliminary cutaneous incision and exposing the crico-thyroid membrane for examination. In children the crico-thyroid space is very small, and the hoop of the cricoid cartilage must be cut through if it is desired to insert a canula. The mucous lining at the top of the trachea is so loose that a canula may be introduced between it and the membrane instead of entering the trachea. This in fact has happened at the hands of skilful operators. The *veins of the larynx* accompany the arteries, and terminate in the *superior, middle,* and *inferior thyroid veins.*

The *nerves of the larynx* are the branches of the superior or descending and inferior (recurrent) or ascending laryngeal branches of the pneumogastric nerve. The *superior laryngeal nerve* arises from the inferior ganglion of the pneumogastric nerve, descends by the side of the pharynx between the middle and inferior constrictor muscles, in close company with the superior laryngeal artery, and divides into the internal and external laryngeal nerves. The *internal laryngeal nerve* penetrates the thyro-hyoid membrane, with the internal branch of the artery, and endows the mucous membrane throughout the larynx with sensibility, which is normally very acute in the folds about the epiglottis, so that the entrance of the air-passage is guarded against the danger of food passing the wrong way in the act of deglutition. Whenever a foreign body, such as a crumb or a fish-bone, touches the mucous membrane of the larynx, it induces a spasmodic cough and an involuntary attempt to expel it. The sensibility of the lining mucous membrane is, however, variable, and it is remarkable that when foreign bodies are retained within its folds their presence is not only tolerated, but the patient in a little while becomes unconscious of them. It is owing to this fact that the modern method of "intubation" for the relief of stenosis of the larynx is at all feasible. It is probable, too, that the usual sensibility of the mucous membrane is diminished when the parts are œdematous from inflammation. The branches of the internal laryngeal nerve form plexuses beneath the epithelial layer of the mucous membrane, terminate either in end-bulbs or bodies resembling the taste-buds of the tongue, and are surrounded with ganglionic cells. There are fewer of these in relation to the true vocal cords than elsewhere in the larynx. This nerve is connected with the inferior laryngeal nerve by a filament which passes downward behind the ala of the thyroid cartilage, and another filament usually pierces the arytænoideus muscle, probably supplying it. The *external laryngeal nerve*, after descending beneath the depressor muscles of the larynx, supplies mainly the crico-thyroid muscle. It furnishes a twig also to the adjacent lobe of the thyroid body.

The *inferior* (or *recurrent*) *laryngeal nerves* arise from the pneumogastric nerves at the root of the neck (Plates 32, 33, 35, and 40), but

differ in their relations upon the two sides. The *right* inferior laryngeal nerve leaves the pneumogastric at the lower border of the subclavian artery, near its origin from the innominate artery, and takes an oblique course upward *under* the subclavian and inferior thyroid arteries to the side of the trachea. The *left* inferior laryngeal nerve leaves the pneumogastric at the lower border of the arch of the aorta, about the commencement of its descending portion, and winds upward *under* it toward the trachea. On both sides the nerves occupy the groove between the trachea and the œsophagus (Plate 24, Fig. 2), and enter the larynx beneath the inferior constrictor muscle, sending branches to all the intrinsic laryngeal muscles except the crico-thyroid, as already stated (page 180).

The *recurrent* course of the inferior laryngeal nerves has attracted the attention of anatomists from the time of Galen, and many different explanations for it have been offered. It is probably due to the variations that take place commensurate with the developmental changes in the branchial apparatus of the embryo in this region, and the *normal* courses of these nerves, upon the right and left sides, as above given, are consequent upon the relations of the great arteries at the root of the neck. It has been observed that when these arteries vary in their origin, especially the right subclavian, the right inferior laryngeal nerve is not recurrent, but leaves the right pneumogastric opposite the cricoid cartilage.

The *lymphatic vessels of the larynx* accompany the veins and end in the deep cervical lymphatic glands about the lateral lobes of the thyroid body.

Being situated between the trachea and the hyoid bone, which supports the tongue, the larynx is consequently subordinated to the movements of that organ. The mobility of the larynx is necessary for the acts of swallowing and speaking. During the latter act the larynx is raised in the emission of high sounds and lowered in that of deep sounds. During swallowing, the larynx is raised upward and forward. In moving forward it opens the orifice of the gullet so that it can receive the bolus of food, and in moving upward it meets the base of the tongue, which closes the epiglottis over the glottis so that particles of the food cannot enter the respiratory apparatus. The mobility of the larynx renders

operations on the organ very difficult, and it is essential in all such that the organ should be first steadied as much as possible.

The trachea is described with the anterior region of the neck (page 236).

THE REGION OF THE NECK.

The *skeleton of the neck* (Plates 1 and 28) is so well covered by the surrounding soft structures (Plates 12 and 14) that its prominences are less conspicuous to external observation than those of any other region of the body. The relations of the component parts of the neck are considerably influenced by the position of the cranium, which is supported, somewhat behind its axis, upon the most flexible portion of the vertebral column. It should be remembered that a line drawn from side to side in front of the mastoid processes will bisect the condyloid processes, and that the upper-jaw teeth are on a line with the foramen magnum at the base of the skull. If a horizontal section of the neck is made about the level of the fifth cervical vertebra (Plate 14, Fig. 1, No. 1), the segment of the body of that vertebra will be found in the *anterior part* of the section, together with the gullet, windpipe, great vessels, nerves, and glands, while the muscles which hold the head erect upon the spine will occupy principally the posterior part.

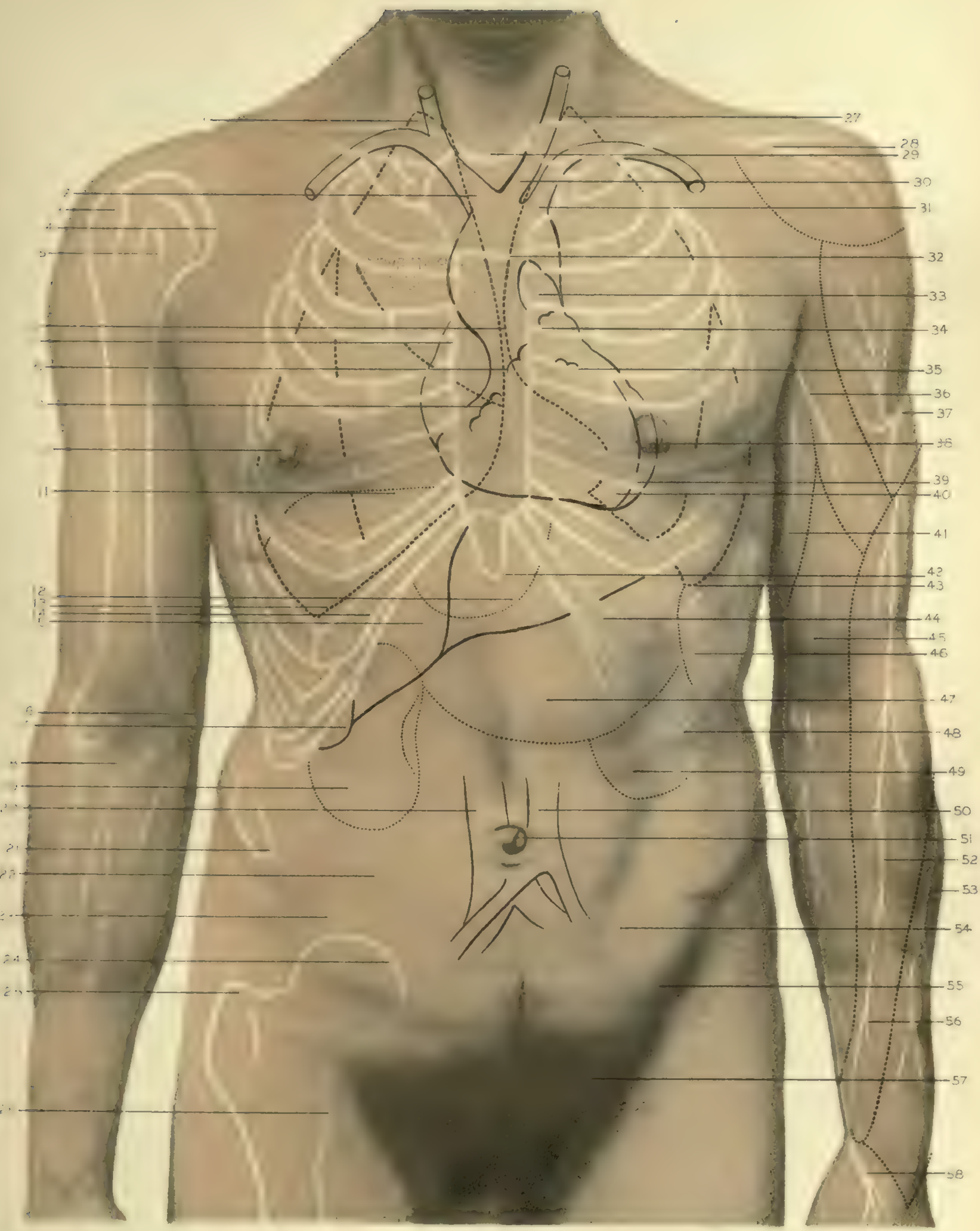
The bony landmarks of the neck are very few, but they are very important. They can be ascertained by pressure or manipulation, and by changing the relative positions of the head and trunk.

When the body is upright, with the shoulders squared and the head held so that the face looks straight forward, a line drawn obliquely from the occipital protuberance along the body of the lower jaw to the chin is about parallel with a line drawn from the lower border of the first dorsal vertebra to the top of the sternum; and these two lines may be considered as the upper and lower limits of this region. The atlas vertebra cannot be felt at the back of the neck through the external parts, but by bending the head forward or backward the spinous processes from the second to the seventh cervical vertebra can be readily detected. The seventh vertebra is always so well marked (Plate 1, No. 15) that it has received

PLATE 27.

A topographical survey of the anterior surface of the body of a well-developed adult male, with especial reference to the clinical study of the relations of the thoracic and abdominal viscera. Also showing the relations of the bones to the surface of the right upper extremity, and the localization of the areas of distribution of the sensory nerves on the anterior surface of the left arm and forearm.

1. The apex of the right lung above the clavicle.
2. The position of the innominate artery.
3. The position of the greater tuberosity of the humerus.
4. The position of the head of the right humerus.
5. The position of the lesser tuberosity of the humerus.
6. The approximation of the lungs over the root of the heart, in full inspiration.
7. The junction of the right third costal cartilage with the sternum, corresponding to the position of the base of the heart.
8. The position of the aortic semilunar valves.
9. The position of the right auriculo-ventricular valve.
10. The right nipple.
11. The position of the upper surface of the liver in relation to the right arch of the diaphragm.
12. The position of the lesser curvature of the stomach.
13. The extent to which the lower lobe of the right lung descends in full inspiration, parallel with the lower border of the cartilage of the sixth rib.
14. The cartilage of the right seventh rib.
15. The position of the right lobe of the liver.
16. The internal condyle of the right humerus.
17. The position of the fundus of the gall-bladder, in relation to the right eighth costal cartilage.
18. The position of the head of the radius.
19. The position of the lower portion of the right kidney.
20. The position of the lower portion of the inferior vena cava.
21. The superior anterior spine of the right ilium.
22. The position of the cæcum and the vermiform appendix.
23. The position of Poupart's ligament.
24. The head of the right femur.
25. The greater trochanter of the femur.
26. The lesser trochanter of the femur.
27. The apex of the left lung above the clavicle.
28. The cutaneous area of the distribution of the external supra-clavicular nerve.
29. The supra-sternal notch.
30. The position of the left common carotid artery.
31. The position of the left subclavian artery.
32. The ridge between the manubrium and the gladiolus of the sternum.
33. The position of the pulmonary artery.
34. The position of the semilunar valves of the pulmonary artery.
35. The position of the left auriculo-ventricular valve.
36. The area of the distribution of the lesser cutaneous nerve.
37. The cutaneous area of the distribution of the circumflex nerve.
38. The left nipple.
39. The junction of the left fifth rib with its cartilage.
40. The normal position of the apex beat of the heart.
41. The cutaneous area of the distribution of the intercosto-humeral nerve.
42. The tip of the ensiform cartilage.
43. The extent to which the lower lobe of the left lung descends in full inspiration.
44. The cartilage of the left seventh rib.
45. The cutaneous area of the distribution of the internal cutaneous nerve.
46. The position of the spleen in relation to the left eighth, ninth, and tenth ribs.
47. The position of the stomach in relation to the anterior wall of the abdomen.
48. The cartilage of the left ninth rib.
49. The position of the lower portion of the left kidney.
50. The position of the abdominal aorta in relation to the body of the second lumbar vertebra.
51. The umbilicus.
52. The cutaneous distribution of the musculo-cutaneous nerve on the anterior surface of the forearm.
53. The lower part of the cutaneous area of the distribution of the musculo-spiral nerve.
54. The position of the sigmoid flexure of the colon.
55. The position of the internal abdominal opening.
56. The lower part of the cutaneous area of the distribution of the musculo-cutaneous nerve.
57. The position of the external abdominal opening.
58. The upper part of the cutaneous area of the distribution of the radial nerve.



Photographed and Designed from Nature by GEORGE MC CLELLAN M.D.

Armstrong & Co. Lith. Boston

the special designation of the *vertebra prominens.* Owing to the obliquity of the spinous process of the fifth vertebra, it is on a level with the disk between the bodies of the fifth and sixth. On the sides the transverse process of the atlas vertebra can be felt in front of and below the mastoid process, and by deep pressure in the supra-clavicular fossa the transverse process of the seventh vertebra can be distinguished. About a finger's breadth above the latter, the head being moved from side to side, the anterior tubercle of the sixth vertebra is perceptible to the touch, which, because of its relation to the overlying carotid artery, is known as the "carotid tubercle."

In the *front of the neck* the hyoid bone and the external cartilages of the larynx, the thyroid and cricoid, offer reliable indications to the position of the deep vessels and adjoining parts; but, owing to the mobility of these structures, which permits of their accommodation to the efforts of swallowing and of forced respiration, and to the changes of position in consequence of the flexibility of the cervical vertebræ, their relation to the chin above and to the top of the sternum below should be carefully noted. In the *adult*, when the head is in the erect position, the body of the hyoid bone, with its greater cornua, can be felt just below the body of the lower jaw. About two centimetres, or three-quarters of an inch, below it is the top of the thyroid cartilage, the anterior notch of which, or *pomum Adami*, is recognizable,—but always more prominent in the male than in the female. At the lower border of the thyroid cartilage there is a depression corresponding to the crico-thyroid membrane, which intervenes between it and the *hoop of the cricoid cartilage* (page 177). The latter is the most important landmark in the anterior part of the neck, as it is easily detected in fat as well as in lean persons, of both sexes, and at all periods of life. In drawing a comparison between the relative bearing of these parts in the child and in the adult, it should not be overlooked that the larynx is undeveloped before puberty, and that the changes in the jaws as to the size and shape of their rami and the progressive development of the alveolar processes have much to do with the relative position of some of the parts in the vicinity. In bending back the head *in the adult* (Plate 53, Fig. 1, and Plates 23 and 24), the space between the top of

the sternum and the chin is about double that which it measures when the head is in the natural position, and it is chiefly increased between the chin and the cricoid cartilage. In the child, however, with the head similarly placed the space is increased between the cricoid cartilage and the top of the sternum, because in the child the cricoid cartilage occupies relatively a higher position in the neck, owing to the diminutive size of the larynx. As the larynx becomes developed, the cricoid cartilage is depressed toward the sternum, and the trachea, as well as the other parts of the neck, assumes the adult arrangement. The distance between the cricoid cartilage and the sternum is not more than four centimetres, or an inch and a half, in the ordinary carriage of the head, and when the neck is stretched it is increased very little over twelve millimetres, or half an inch. The upper portion of the trachea can usually be felt just below the cricoid cartilage, but its separate rings are indistinguishable, in consequence of the trachea receding as it descends, so that at the root of the neck it is at a considerable distance from the surface (Plates 24 and 25). When the head is upright the cricoid cartilage is about opposite the spine of the fifth cervical vertebra (Plates 1 and 12); when the head is bent backward, so as fully to extend the neck, the cricoid cartilage is raised opposite the fourth vertebra; and when the head is bent forward until the chin touches the breast the cricoid cartilage is depressed, and corresponds to the sixth vertebra. The general development of the neck varies in different individuals, being commensurate with the stature.

The difference in the length of the neck in the adult is sometimes more apparent than real, frequently resulting from some peculiarity in the conformation of the shoulders. Its breadth is often variable. In children the comparative length of this region is due to the slight development of the face, the larynx being connected with the tongue and the hyoid bone; and it is important to note that in childhood the top of the manubrium sterni is higher in relation to the vertebral column than in the adult.

The skin over the *anterior portion* of the cervical region is thin, delicate, and very elastic, being so loosely attached by the superficial fascia to the deep fascia enveloping the underlying structures that it is readily raised in folds. The amount of fat in the subcutaneous tissue

varies in different localities, but it is apt to become diffused above the hyoid bone, where it forms the redundancy called "double chin." In marked contrast to the skin in front is that over the *nape* of the neck, where it is very dense and adherent to the sheaths of the muscles beneath, so that when the head is turned backward the skin is thrown into parallel transverse folds (Plate 53, Fig. 1). The peculiar toughness and low vascularity of the superficial fascia in the latter locality render it liable to become the seat of carbuncle, in consequence of which it is sometimes called the "carbuncular tissue."

In close connection with the skin in front and at the sides of the neck is the thin cutaneous muscle called the *platysma myoides* (Plate 17, No. 7, and Plate 23, Fig. 1, No. 9). This muscle usually arises from the skin over the chin, the body of the jaw, the cheek, and the masseteric fascia, its fibres descending outward and forming a continuous sheet, which is spread over the lateral portion of the neck and is inserted into the subcutaneous tissue over the pectoralis major and deltoid muscles. A few of the fascicles of the upper portion blend with the tissues about the angle of the mouth and radiate backward, being separated from the rest of the muscle, and forming the *musculus risorius* (page 121). Anteriorly the fibres are very sparse and thin and cross those of the opposite platysma; and below the chin they are frequently developed into muscular slips, forming the so-called *sphincter colli.* This muscle serves as a protective covering to the neck. It is supplied with nerves from the cervical plexus and the cervical branch from the facial nerve, over which it lies. Within the meshes of the platysma the external jugular vein appears, when it holds its usual course, in a line from the angle of the jaw to the middle of the clavicle (Plate 17, No. 5). The blue outline of this vein is almost always perceptible in life through the skin, and it is especially pronounced during the acts of speaking, singing, and coughing. Also when the breath is held and any great effort is made, these veins, as well as those of the forehead, become swollen. When the platysma is removed, the deep cervical fascia is seen forming a close investment, having upon it the superficial branches of the cervical plexus of nerves and the external and anterior jugular veins (Plate 23, Fig. 2, No. 34). The *external jugular vein* is

formed by the junction of the temporal and internal maxillary veins in the substance of the parotid gland (page 134), at the lower border of which it receives the transverse facial and posterior auricular veins. It crosses obliquely the sterno-mastoid muscle, and generally takes a perpendicular course to about half an inch above the middle of the clavicle, where it pierces the deep fascia and terminates in the subclavian vein. Sometimes this vein joins the common jugular vein before it empties into the subclavian, in which case the external jugular follows along the posterior border of the sterno-mastoid muscle. The external jugular has two pairs of valves: the lower, near its termination, are imperfect, but the *upper*, four centimetres, or about an inch and a half, above the clavicle, are more complete. Near the angle of the jaw the *submaxillary vein* (Plate 18, No. 17) establishes a communication between the external jugular and facial veins.

The *occipital vein* joins the external jugular about the middle of its course, and in the supra-clavicular fossa there is a confluence of veins which are tributaries to it from the scapular region, and which are of importance because they overlie the subclavian artery in the place where it is usually sought (Plate 17, No. 8). The *auricularis magnus nerve* turns round the posterior border of the sterno-mastoid muscle where the external jugular vein crosses it, and passes upward to the parotid gland in close proximity to the vein. The *superficial cervical nerve* passes under the vein at this point, and divides into cutaneous branches which supply the anterior surface of the neck (Plate 18, No. 26, and Plate 23, Fig. 2, No. 31). The *anterior jugular vein* is usually insignificant, but it bears a compensating supplemental relation to the external jugular, being enlarged when that vein is small or deficient. There are sometimes two anterior jugular veins running side by side along the anterior median raphé of the neck, having short cross links between them above the sternum. The anterior jugular ends either in the external jugular or in the subclavian beneath the sternal end of the sterno-mastoid muscle.

The cutaneous nerves of the neck are the superficial branches of the cervical plexus, which is formed by the intercommunication of the anterior divisions of the four upper cervical nerves under the sterno-mastoid

muscle, and cannot be displayed unless that muscle is turned aside (Plates 20 and 21).

The upper cervical nerves, the most important of which is the *great occipital nerve*, pertain more especially to the nape of the neck (Plate 22, Fig. 1, Nos. 3 and 12). The nerves which supply the anterior part of the neck appear at the posterior border of the sterno-mastoid muscle, and are arranged in branches which pass upward, forward, and downward, forming what is sometimes called the *pes anserinus cervicis*. The great auricular and superficial cervical nerves are derived from the second and third cervical nerves, and have been described in connection with the external jugular vein. The *small occipital nerve* comes from the second cervical nerve, and ascends along the posterior border of the sterno-mastoid muscle to the back of the ear, communicating with the great occipital and posterior auricular nerves (Plate 53, Fig. 1). It also sends a deep branch to the spinal accessory nerve. The descending branches are derived from the third and fourth cervical nerves, and divide into the *sternal*, *clavicular*, and *acromial nerves*, which supply the skin respectively in the neighborhood of the sternum, clavicle, and acromion (Plates 18, 19, and 23). The cervical branch of the facial nerve (Plate 19) pierces the deep fascia at the parotid gland, and, passing near the angle of the jaw, arches over the upper part of the neck, supplying the platysma and the skin, and joins the superficial cervical nerve.

There are a few *superficial lymphatic glands* in relation to the external and anterior jugular veins which lie external to the deep cervical fascia.

The deep fascia in the cervical region, as elsewhere in the body, constitutes an aponeurotic envelope over all the deeper parts, binding them in position and preserving their relations to one another. From its under surface are reflected over each structure prolongations peculiarly modified to suit their several functions, so that they are encased in appropriate sheaths. In certain localities these prolongations are more strongly developed than in others, and by having special attachments play an important part in the mechanism of this complex region. In others they form dense partitions so arranged that they offer protection against the evil effects of atmospheric pressure. It should be understood that this

is not an uninterrupted membrane, consisting of complete laminæ, and that not only is it modified and adapted to the requirements of muscles, vessels, etc., but it is also here and there pierced by vessels and nerves upon which it is reflected, and thus establishes communications between its own recesses and those of the adjacent regions, the thorax and the axillæ.

The localities in which the deep fascia is particularly strong and resisting are about the angle of the jaw, in front of the trachea, and in the supra-clavicular fossa. The special attachments of this fascia are of interest, as they often afford an explanation of the course which matter takes when it forms in the neck; but much undue weight has been given to them in this respect, for they do not by any means always set up efficient barriers against or form natural passage-ways for the course of pus as usually described. It is true, however, that here, as elsewhere, inflammatory action may induce plastic thickening in the deep fascia which limits the growth of tumors and modifies the direction of their progress. The fascia is attached posteriorly to the ligamentum nuchæ and to the spinous processes of the cervical vertebræ, closely adhering to the subjacent muscles at the nape of the neck, and passes forward until it reaches the sterno-mastoid muscle. There it splits into two layers, an *external* and an *internal*, which respectively pass over and under the sterno-mastoid muscle, and, uniting at its anterior border, so as to form for it a distinct sheath, split again into lamellæ, which in turn separate into leaflets. The *external layer of the deep fascia* is attached *above* to the mastoid process and adjacent part of the occipital bone, to the zygoma, forming in relation to the parotid gland the parotid fascia (page 130), and to the border of the lower jaw. In the middle line of the neck this layer blends with the corresponding layer from the opposite side and becomes closely connected with the body of the hyoid bone. It forms sheaths for the sterno-hyoid and sterno-thyroid muscles, and is attached below to the clavicle and the top of the sternum. Below the thyroid body the external layer of the fascia is divided into two lamellæ, which are inserted at the front and back borders of the top of the sternum, including the sternal attachment of the sterno-mastoid muscle on each

side. This corresponds to the supra-sternal notch, and the interval between the layers of fascia in this locality contains a few lymphatic glands embedded in a variable quantity of fat, besides being traversed by the anterior jugular vein. The *internal layer of the deep fascia* is very complicated, as it separates into many subdivisions, which are in some instances prolonged to join corresponding offsets from the fascia of the opposite side and in others to blend with the deep fascia of adjacent regions. Above it is attached to the base of the skull, and extends from the styloid process to the angle of the jaw, forming the *stylo-maxillary ligament*. It is prolonged, as the *prevertebral fascia*, over the longus colli muscles, separating them from the posterior wall of the pharynx, and descends behind the œsophagus into the thorax, where it joins with the anterior common spinous ligament. It is extended across the trachea under the sterno-thyroid muscles, and invests the thyroid body.

The cellular tissue between the prevertebral fascia and the pharyngeal constrictor muscles is loose, and the seat of post-pharyngeal or retro-pharyngeal abscesses, which instead of opening into the pharynx are often guided by the fascia behind the carotid vessels to the outer surface of the neck. A reflection of the prevertebral fascia has an attachment to the transverse processes of the cervical vertebræ which forms sheaths for the scaleni muscles and extends over the cords of the brachial plexus of nerves, to blend with the costo-coracoid membrane in relation to the subclavius muscle. The *sympathetic nerve* is placed between the prevertebral and post-pharyngeal layers of the fascia.

In relation to the carotid artery, internal jugular vein, and pneumogastric nerve an expansion is given off from the under surface of the sheath of the sterno-mastoid muscle which blends with a leaflet from the prevertebral fascia and becomes considerably condensed, so that it forms a common sheath for these structures, which are also separated from one another by delicate septa. By means of the carotid sheath this layer of the deep cervical fascia becomes continuous with the pericardium, and the heart thus receives support from both sides of the neck.

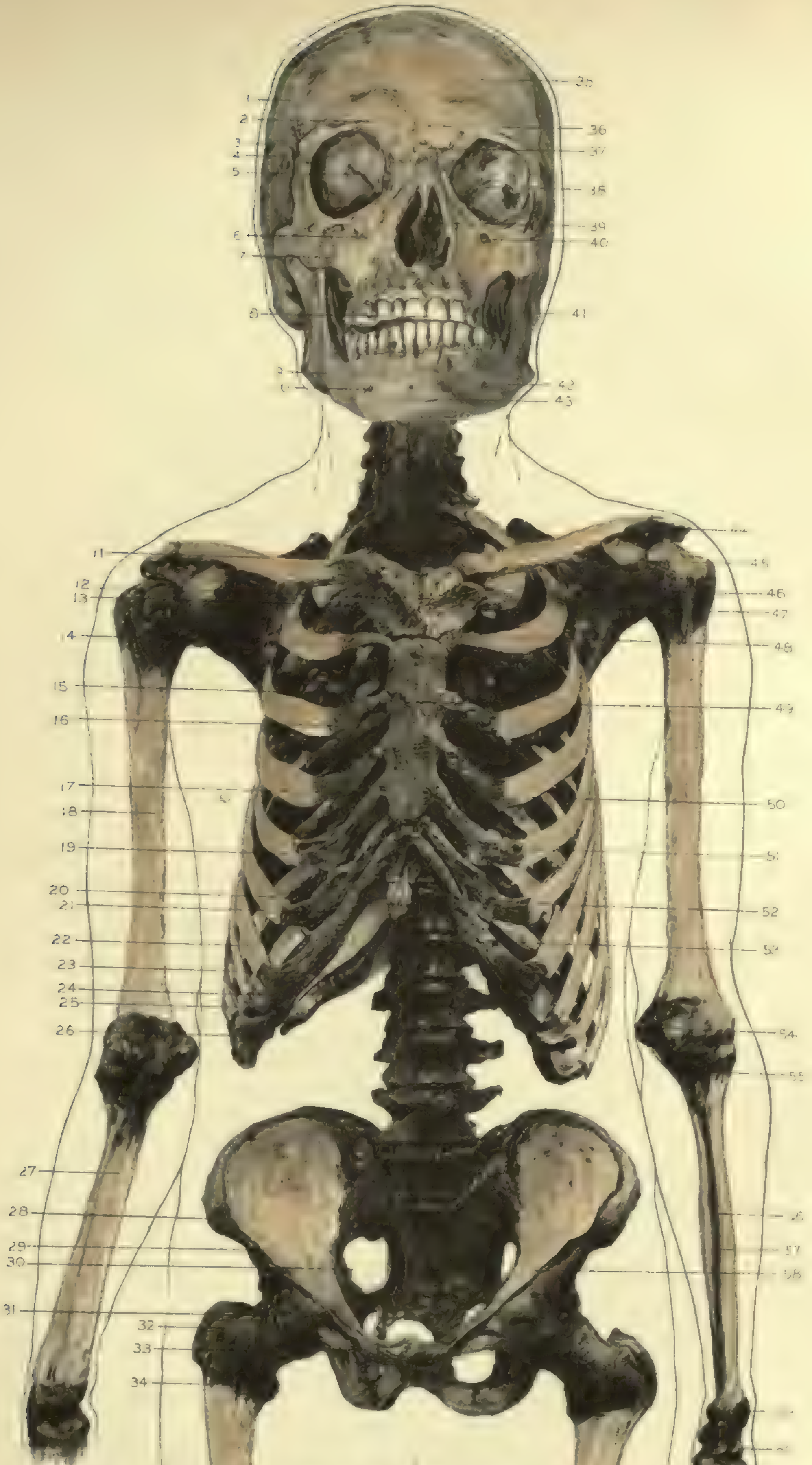
A reflection of the fascia is looped over the intermediate tendon of the omo-hyoid muscle, which it binds to the first rib, and is prolonged

PLATE 28.

Front view of a natural (ligamentous) skeleton of a European male aged thirty-eight years, showing the landmarks with their relations to the surface coverings.

1. The right temporal ridge.
2. The right supra-orbital foramen.
3. The squamous suture.
4. The external angular orbital process.
5. The sphenoidal fissure in the back of the right orbit.
6. The infra-orbital foramen.
7. The right malar bone.
8. The incisor teeth.
9. The angle of the lower jaw—the *gonion*.
10. The mental foramen.
11. The right clavicle.
12. The manubrium sterni.
13. The sternal end of the first rib.
14. The second rib.
15. The junction of the cartilage of the third rib with the sternum (corresponding to the position of the base of the heart).
16. The third rib.
17. The fourth rib. (This line passes over the right nipple.)
18. The right humerus.
19. The right fifth rib.
20. The right sixth rib.
21. The ensiform cartilage.
22. The right seventh rib.
23. The right twelfth rib.
24. The right eighth rib.
25. The right ninth rib.
26. The cartilage of the right tenth rib.
27. The right radius.
28. The anterior superior spine of the ilium.
29. The anterior inferior spine of the ilium.
30. The great sciatic foramen.
31. The lesser sciatic foramen.
32. The great trochanter of the femur.
33. The ilio-femoral ligament, over the capsular ligament of the hip.
34. The lesser trochanter of the femur.
35. The left frontal eminence.
36. The glabella.
37. The nasion.
38. The sphenoidal fissure in the back of the left orbit.
39. The septum nasi.
40. The infra-orbital foramen.
41. The ramus of the inferior maxillary bone.
42. The mental foramen.
43. The symphysis of the lower jaw.
44. The acromion process of the scapula.
45. The coracoid process of the scapula.
46. The sternal end of the first rib.
47. The venter of the left scapula.
48. The sternal ridge at the junction of the first and second pieces of the sternum.
49. The gladiolus.
50. The fourth rib. (This line passes over the left nipple.)
51. The junction of the left fifth rib with its cartilage (where the apex of the heart beats in life).
52. The left sixth rib.
53. The cartilage of the left seventh rib.
54. The internal condyle of the left humerus.
55. The head of the radius.
56. The left radius.
57. The left ulna.
58. The left Poupart ligament.
59. The styloid process of the radius.
60. The left carpus.

N.B.—In this preparation, owing to the effect of drying, the second, third, and fourth costal cartilages are not in the lines of their ribs, as they are found to be in the recent state. Compare Plate 29.



Dissected, Photographed and Colored from Nature by George McClellan M.D.

over the subclavian vessels into the axilla. Back of the sternum there is a continuation of this layer of the deep fascia, which passes along the anterior mediastinum: the pus from a cervical abscess will sometimes travel along this route and point at the side of the xiphoid appendix on the surface of the abdomen. The arrangement of the layers of the deep cervical fascia in relation to the top of the sternum, to the first rib, and to the clavicle is such that the soft parts at the upper opening of the chest are protected against the pressure of the atmosphere during inspiration.

The deep cervical fascia is not normally strong and unyielding, and cannot properly be compared with the fascia lata, but it may become so under the influence of pressure and inflammation; and in many instances where growths or abscesses in this region have been influenced in their course by the denseness of the surrounding fascia, the growth or abscess has itself induced the change. This is especially noticeable where the morbid condition has become chronic.

The *sterno-cleido-mastoid muscle* (Plates 16, 18, 19, and 23) is the great muscular landmark at the side of the neck, which serves as a guide to the position of the important vessels with which it is in immediate relation. It arises by a thick, round tendon from the upper and outer surface of the manubrium sterni, internal to the sterno-clavicular joint, and by a flat, fleshy, and tendinous origin from the adjacent portion of the clavicle. Between these origins there is a variable interval, which is filled with a double layer of the cervical fascia. The sternal fibres ascend over the sterno-clavicular joint and join with the clavicular fibres, so that at the middle of the muscle its substance is strong and somewhat contracted, but toward its insertion it flattens out, to be attached to the mastoid process, the temporal bone behind the process, and the contiguous part of the upper curved line on the occipital bone. The fibres composing the external and clavicular portions, if carefully examined, will be found to overlap one another, so that the sternal fibres occupy the outer and more conspicuous position, while the clavicular fibres are deeper and mainly attached to the apex of the mastoid process. These peculiarities of the insertions of the fibres of this muscle explain the different actions of which it is capable. This will be better understood by referring to the landmarks of the articu-

lated skeleton (Plate 1) than by referring to a detached skull (Plate 2), and it should be remembered that a line drawn from one mastoid process to the other will bisect the condyloid processes, as previously stated, and that the vertical axis of the skull corresponds to a perpendicular line from the vertex to the inter-mastoid line. Ordinarily the united action of the two sterno-mastoid muscles maintains the head in the erect position with the face directed forward, but if the action of the sternal fibres, which are attached to the temporal and occipital bones behind the mastoid process, is greatest, the head will be tilted backward, with the face upward, while if the action of the clavicular fibres, which are inserted into the apex of the mastoid process, predominates, the head will be bowed forward. This action is marked in raising the head from the recumbent position, and both actions may be demonstrated by the application of electrical stimulation (Plate 53, Fig. 1). In considering the action of the sterno-mastoid muscle the expansion of the deep fascia, which connects the upper part of its anterior border with the lower jaw, should not be overlooked, for it probably assists materially the clavicular fibres. The action of one sterno-mastoid muscle draws the head obliquely toward the opposite shoulder, co-operating with the splenius muscle of the other side. The condition known as "wry-neck" is generally due to the spasmodic contraction of one sterno-mastoid muscle. When the head is fixed, the sterno-mastoid muscles elevate the sternum in forced inspiration. Each muscle is supplied principally by the spinal accessory nerve, which enters close to the mastoid process, together with the sterno-mastoid branch of the occipital artery. It also receives nerves from the second and third cervical nerves, and arteries from the superior thyroid and supra-scapular arteries.

The *side of the neck* may be considered as divided by the oblique direction of the sterno-mastoid muscle into triangular spaces, the anterior and posterior cervical triangles. The *anterior triangle* is inverted, its base being formed by the body of the lower jaw, and its sides by the middle line and the anterior border of the sterno-mastoid. The *posterior triangle* has the clavicle for its base, while its sides are defined by the posterior border of the sterno-mastoid and the anterior border of the trapezius muscle (Plate 16). The neck is further subdivided into smaller

triangles by the disposition of the digastric and omo-hyoid muscles beneath the sterno-mastoid. The *digastric muscle* consists of two muscular portions, united by an intermediate tendon, which pierces the tendon of the stylo-hyoid muscle and is attached to the body of the hyoid bone by a loop of the deep fascia (Plate 25, No. 4). The *posterior* portion arises from the digastric fossa on the temporal bone, back of the mastoid process. The *anterior* portion is attached to the lower jaw near the symphysis. These two portions, with the body of the lower jaw, constitute the *submaxillary* or *digastric triangle*. When the platysma is removed from this locality the deep fascia presents a dense covering to the contents of this space, the chief of which is the *submaxillary salivary gland* (Plate 18, No. 20, and Plate 13, Fig. 2, No. 6), which has already been described (page 164), as well as the relations of the facial and lingual arteries, for which this triangular space is usually topographically surveyed. The submaxillary vein, which joins the facial vein with the external jugular, is in the superficial fascia, in close proximity to the jaw (Plate 18, No. 17), and there are from six to ten lymphatic glands (Plate 16), some above and some beneath the salivary gland, which receive the lymphatic vessels from the face, the tongue, and the tonsils, already spoken of in the description of these parts. The *stylo-hyoid muscle* is a slender band of fibres, originally separated from the posterior portion of the digastric, with which it is in close relation at its inner side. Its upper attachment is at the outer and back surface of the styloid process, and its lower at the body of the hyoid bone near the lesser cornu, where it is pierced by the middle tendon of the digastric. The nerves which supply the posterior portion of the digastric and the stylo-hyoid muscles come from the facial nerve, and leave the lower border of the parotid gland immediately above. These muscles overlie the external and internal carotid arteries, the internal jugular vein, and the pneumogastric and hypoglossal nerves (Plate 13, Fig. 2, and Plate 22, Fig. 2). The anterior portion of the digastric muscle is superficial, and rests upon the mylo-hyoid muscle anterior to the submaxillary gland (Plates 23 and 25). The inner margins of the anterior portions of the two digastric muscles are often connected by fleshy fibres, but generally by connective tissue. Their nerves are derived from the mylo-hyoid nerves. The anterior and pos-

terior portions of the digastric muscle always act together, but the effect of their action depends upon which two of the three points of attachment are fixed. If the jaw and skull are both fixed, the muscle raises the hyoid bone, as in swallowing; if the skull and hyoid bone are fixed, the lower jaw is depressed, as in yawning; if the chin is supported so that the jaw and hyoid bone are fixed, the muscle can draw the skull backward. The digastric and stylo-hyoid muscles, with the mylo-hyoid and genio-hyoid muscles, described in relation to the tongue (page 165), are classified as the *supra-hyoid muscles.*

The *omo-hyoid muscle* is digastric, consisting of two fleshy portions connected by an intermediate tendon. Its *posterior* portion arises beneath the trapezius muscle from the superior border of the scapula, usually including the supra-scapular notch and its ligament, and passes forward and upward to the level of the cricoid cartilage, being attached to the clavicle by a fold of deep fascia which loops around its intermediate tendon under the sterno-mastoid muscle. The *anterior* portion passes vertically upward close to the outer border of the sterno-hyoid muscle, and is attached to the lower border of the hyoid bone. The course of this muscle does not change in contraction, and always maintains an obtuse angle, so that it is a reliable guide to the position of the great carotid vessels, directly *over* the sheath of which it passes at the point where the anterior and posterior portions of the muscle meet, on a level with the cricoid cartilage, as just stated. The fascial expansion which binds the central tendon to the clavicle is usually reflected to the first rib, and appears to offer resistance to the pressure of the atmosphere upon the internal jugular vein and the apex of the pleura which it covers. Occasionally fleshy fibres are developed in this reflection of the fascia. The contraction of the omo-hyoid muscles takes place only during inspiration, and, owing to their influence upon the fascia enveloping the great venous trunks at the root of the neck, a dilatation of these vessels is coincident with the dilatation of the thorax, so that the flow of the blood toward the heart is facilitated. This also indicates the danger of the entrance of air in wounds involving these veins. The subdivisions of the side of the neck which may be mapped out by the disposition of the omo-hyoid muscle are known as the superior

and inferior carotid triangles anterior to the sterno-mastoid muscle, and the occipital and supra-clavicular triangles posterior to it. The *superior carotid triangle* has for its three sides the posterior portion of the digastric muscle, the sterno-mastoid muscle, and the anterior portion of the omo-hyoid muscle. The *inferior carotid triangle* is bounded by the omo-hyoid and sterno-mastoid muscles, above and below, and in front by the middle line of the neck.

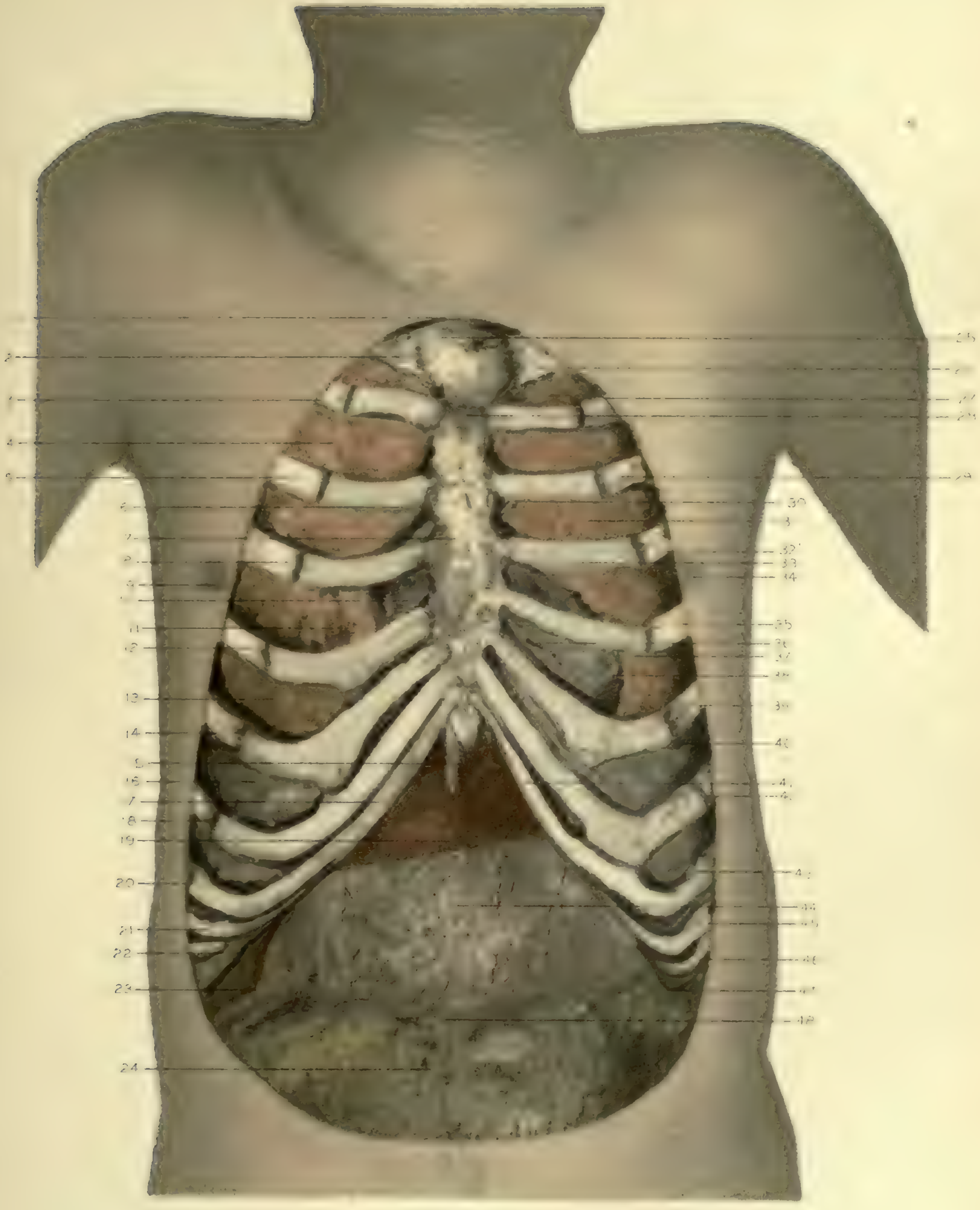
These *carotid triangles* have been so called because they were considered to bear reference to the course of the carotid artery and the internal jugular vein, and to elucidate the topographical study of this very complex region. They are very misleading, and time is often wasted in attempting to acquire or recall their boundaries. The carotid artery is not within the limits of the inferior triangle at all, as the sternal end of the sterno-mastoid muscle completely overlaps the sheath of the great vessels, which is in reality in relation to the interval between the sternal and clavicular origins of that muscle. A needle introduced upon the right side above the clavicle through this interval would pierce the bifurcation of the innominate artery, and on the left side the common carotid artery (Plate 14, Fig. 2, No. 6). The course of the carotid arteries on both sides from this point to their bifurcation is similar, and approximately may be considered as corresponding to the anterior borders of the sterno-mastoid muscles when either of them is brought into relief by turning the head to the opposite side. A line drawn transversely across the neck from the fifth cervical vertebra to the cricoid cartilage will indicate the position where the omo-hyoid muscle crosses the sheath of the great vessels. Above this point the carotid artery is superficial; below it is deeply placed and covered with a quantity of fatty tissue containing many veins, nerves, and lymphatics. It is this point of crossing of the omo-hyoid muscle which should be sought for in any operation upon the carotid artery; and by making an incision opposite the cricoid cartilage along the border of the sterno-mastoid muscle it can be readily reached. The *bifurcation* of the common carotid into the external and internal carotid arteries usually occurs opposite the top of the thyroid cartilage, which is on a level with the body of the third cervical vertebra, but it may be a little above or

PLATE 29.

The anterior wall of the thorax and upper part of the abdomen removed to show the relations of the heart, lungs, diaphragm, liver, stomach, and spleen to the ribs and their sternal cartilages. The lungs are inflated (as in full inspiration) to indicate the so-called area of the heart's dulness. From a male subject about forty years old, with normal condition of the organs.

1. The supra-sternal notch.
2. The right first rib.
3. The right second rib.
4. The upper lobe of the right lung.
5. The right third rib.
6. The base of the heart.
7. Position of the tricuspid valves.
8. The right fourth rib.
9. The right nipple.
10. The right auricle of the heart.
11. The middle lobe of the right lung.
12. The right fifth rib.
13. The lower lobe of the right lung, resting on the diaphragm and overlapping the liver.
14. The right sixth rib.
15. The ensiform cartilage.
16. The upper surface of the diaphragm, seen through the space between the sixth and seventh ribs.
17. The cartilage of the right eighth rib.
18. The right seventh rib.
19. The left lobe of the liver.
20. The right eighth rib, in this case a *true rib*, having an independent sternal cartilage.
21. The cartilage of the right ninth rib, in its relation to the fundus of the gall-bladder.
22. The cartilage of the right tenth rib.
23. The lower margin of the right lobe of the liver.
24. The great omentum.
25. The manubrium.
26. The left first rib.
27. The left second rib.
28. The ridge at the junction of the manubrium and gladiolus of the sternum, where it receives the cartilages of the second ribs.
29. The left third rib.
30. The position of the pulmonary valves.
31. The upper lobe of the left lung.
32. The left fourth rib.
33. The position of the mitral valve.
34. The left nipple.
35. The left fifth rib.
36. The right ventricle of the heart.
37. The position of the apex beat in the adult.
38. The upper surface of the diaphragm, seen between the fifth and sixth ribs.
39. The left sixth rib.
40. The lower border of the left lung.
41. The cartilage of the left eighth rib, independently connected with the sternum.
42. The left seventh rib.
43. The left eighth rib.
44. The fundus of the stomach, in ordinary distention.
45. The cartilage of the left ninth rib.
46. The cartilage of the left tenth rib.
47. The lower border of the spleen, in its relation to the cartilage of the tenth rib.
48. The branches of the gastro-epiploica dextra artery.

N. B.—The subject upon which this dissection was made presented the rare anomaly of a distinct eighth *true* rib on either side. This is well shown in the plate.



GEORGE McCLELLAN M.D

below this point. The bifurcation is often the seat of aneurism or dilatation, in consequence of the resistance here naturally offered to the current of the blood. The *external carotid artery*, just after its origin, gives off the ascending pharyngeal artery, which runs up between the external and internal carotids to its distribution (page 175), and then in successive order anteriorly the superior thyroid (page 184), lingual (page 166), and facial (page 123) arteries, and terminates in the parotid gland in the internal maxillary and temporal arteries (page 134). Posteriorly the branches from the external carotid are the occipital and posterior auricular arteries (page 8). The relative position which the external and internal carotid arteries hold to each other is worthy of careful notice. At first they are on the same plane, but the external soon crosses in front of the internal to enter the under surface of the upper portion of the parotid gland. The internal ascends close by the side of the pharynx to the base of the skull (Plate 13, Figs. 1 and 3), which it enters by the carotid canal in the apex of the temporal bone. Between the external and internal carotid arteries, just above their bifurcation, there is a long, grayish-colored body, the *inter-carotic body*, which consists of a vascular net-work of tiny vessels from the external carotid, interwoven with some non-medullated nerves and ganglion cells and connective tissue. It is the remains of one of the fœtal visceral clefts. The *internal jugular vein* receives the blood from the brain by the lateral sinus, and commences at the jugular foramen, where it is joined by the inferior petrosal sinus and presents a slight enlargement, the *jugular sinus*. The jugular foramen is formed by the apposition of the jugular fossæ of the occipital and temporal bones, and is behind the opening of the carotid canal, two and one-half centimetres, or about an inch, from the surface over the mastoid process. The vein descends on the outer side of the internal carotid artery, and, after receiving the temporo-facial vein, becomes ensheathed with the common carotid artery, and pursues its course as the *common jugular vein* on the outer side of that vessel, until it empties into the subclavian vein at a right angle and forms the innominate or brachio-cephalic vein. The internal jugular receives the blood from the pharyngeal, occipital, facial, lingual, superior thyroid, and middle thyroid veins.

The jugular foramen also gives exit from the cranium to the pneumogastric, spinal accessory, and glosso-pharyngeal nerves.

The *pneumogastric nerve* (Plate 21, No. 43, Plate 36, No. 61, and Plate 37, No. 32) within the foramen is enclosed in a sheath of the dura mater and arachnoid membrane, with the spinal accessory nerve. There is upon its *root* a small ganglion (Arnold's) which receives a branch from the accompanying nerve. About twelve millimetres, or half an inch, below the ganglion on the root there is another ganglionic enlargement, the *ganglion of the trunk*, which involves only a part of the nerve. The pneumogastric is probably at its origin a nerve of sensation only, but as it is joined by filaments from the hypoglossal and from the first and second cervical nerves as well as from the superior cervical sympathetic ganglion, it becomes a compound nerve and resembles a spinal nerve. It descends upon the rectus capitis anticus major and longus colli muscles in front of the cervical vertebræ, and at the upper part of the neck becomes ensheathed with the internal carotid artery and internal jugular vein, holding a position posterior to them. This position of the pneumogastric nerve is maintained with regard to the common carotid artery and internal jugular vein until the root of the neck is reached, where the nerve, as well as the vessels, holds different relations on the two sides, which are specially described on page 317. In the upper part of the neck the pneumogastric nerve furnishes branches to the ear, to the pharynx, and to the larynx. The *auricular* (Arnold's) branch arises from the lower end of the jugular ganglion, and, passing through a canal in the outer wall of the jugular fossa of the temporal bone, enters the aqueduct of Fallopius and escapes to the outer surface by the auricular fissure, where it communicates with the posterior auricular nerve and supplies the back of the concha (page 63). The *pharyngeal branch* arises from the upper part of the ganglion of the trunk, and, being joined by filaments from the spinal accessory and sympathetic nerves, passes to the inner side of the internal carotid artery and forms the *pharyngeal plexus* upon the middle constrictor muscle (page 175). The *superior laryngeal branch* is derived from the middle of the ganglion of the trunk, and, passing downward behind the internal carotid artery, divides into the internal and external laryngeal

nerves (page 185). In two dissections made within the last year the author has found distinct branches passing from the pneumogastric on the *left* side to the brachial plexus (one of these is seen in Plate 36).

The *glosso-pharyngeal nerve* leaves the jugular foramen in a separate sheath of the dura mater, in front of the spinal accessory and pneumogastric nerves. This nerve at its exit consists of two cords, which coalesce in the jugular foramen and form a double ganglionic swelling, the upper part of which is the *jugular* (or *Ehrenritter's*) *ganglion* and the lower is the *petrosal* (or *Andersch's*) *ganglion*. The trunk of the nerve below the ganglionic enlargement descends between the internal carotid artery and internal jugular vein until it reaches the lower border of the stylo-pharyngeus muscle, whence it is distributed to the tongue (page 167). The *hypoglossal nerve*, after its exit from the skull through the anterior condyloid foramen, is in close connection with the ganglion of the trunk of the pneumogastric beneath the internal carotid artery and internal jugular vein, between which it comes forward and below the posterior portion of the digastric muscle curves round the occipital artery on its way to the tongue (page 167). As it crosses the occipital artery the branch called the *descendens hypoglossi* is given off (Plate 21, No. 41). At first this little nerve enters the sheath of the carotid vessels, but about the level of the hyoid bone it comes through the sheath and runs along on its surface to a point below where the omo-hyoid muscle crosses. This nerve can usually be seen as a white thread on the surface of the carotid sheath, and is generally a reliable indication of its position. The *descendens hypoglossi* forms a loop, the *ansa hypoglossi*, with the communicating branches from the second and third cervical nerves (Plate 21), from which are derived the nerves which supply the omo-hyoid, sterno-hyoid, and sterno-thyroid muscles,—the depressor muscles of the hyoid bone. The descendens hypoglossi appears to consist of fibres mainly derived from a branch from the upper two cervical nerves.

The *spinal accessory nerve* leaves the skull in a common sheath of dura mater with the pneumogastric nerve at the middle of the jugular foramen. The fibres of the original portions of this nerve, the accessory and the

spinal, intermingle at the foramen, but separate into two portions again below the foramen. The *accessory* portion sends a few filaments to join the ganglion at the root of the pneumogastric nerve, and also filaments to the pharyngeal and superior laryngeal branches as they leave the ganglion of the trunk of that nerve. Below the latter ganglion the remaining accessory fibres are incorporated with the pneumogastric. The *spinal* portion, after leaving the accessory, curves backward and outward across the internal jugular vein and the transverse process of the atlas vertebra behind the stylo-hyoid and digastric muscles. It pierces the upper portion of the sterno-mastoid muscle in company with the sterno-mastoid branch of the occipital artery. Leaving the sterno-mastoid muscle, the nerve crosses obliquely the occipital division of the posterior triangular space of the neck to the under surface of the trapezius muscle, and is joined by branches of the second, third, and fourth cervical nerves (Plate 20, No. 58, and Plate 21, No. 10).

The *occipital triangle* is bounded in front, behind, and below respectively by the sterno-mastoid, trapezius, and omo-hyoid muscles. Within this space (Plate 21) are found the deep cervical plexus of nerves, the spinal accessory nerve as above described, and a chain of lymphatic glands in relation to the posterior border of the sterno-mastoid muscle, extending from the mastoid process to the root of the neck (Plate 16). The transversalis colli artery and vein (Plate 25), and the superficial cervical branch from the transversalis colli artery to the trapezius muscle, pass outwardly in the lower portion of this space.

The *deep cervical plexus of nerves* (Plates 20 and 21) consists of intercommunicating branches between the anterior divisions of the upper four cervical nerves, which rest upon the levator anguli scapulæ and scalenus medius muscles, close to the transverse processes of the upper four cervical vertebræ. Each nerve forming the plexus, with the exception of the first, divides into ascending and descending branches. The *superficial* nerves of the plexus have been already described (page 193). The *deep* nerves consist of external and internal branches. The *external* branches are, besides the communicating nerves to the spinal accessory, muscular nerves to the contiguous muscles,—viz., the sterno-mastoid,

scalenus medius, levator anguli scapulæ, and trapezius. The *internal* branches consist of the *communicantes* (from the second and third nerves), which, looping round the internal jugular vein, join the descendens hypoglossi, muscular branches from the first nerve to the prevertebral muscles,—viz., the recti antici, rectus lateralis, and longus colli,—and branches to the hypoglossal, pneumogastric, and sympathetic nerves, and the *phrenic*, which arises from the third, fourth, and fifth cervical nerves and descends toward the root of the neck over the scalenus anticus muscle.

The *supra-clavicular triangle*, called also the *subclavian triangle*, because it contains the subclavian artery, is bounded below by the clavicle, in front by the clavicular origin of the sterno-mastoid muscle, and above by the posterior portion of the omo-hyoid muscle. The area of this space is variable, and depends upon the obliquity of the omo-hyoid muscle and the extent of the clavicular attachments of the sterno-mastoid and trapezius muscles. The contents of the supra-clavicular triangle are described with the other parts at the root of the neck. They, together with the contents of the occipital triangle, rest upon the deep muscles of the neck, the splenius (capitis et colli), the levator anguli scapulæ, the scalenus medius and posticus, and part of the serratus magnus.

The *splenius muscle* (Plate 16, No. 7, Plate 19, No. 25, Plate 22, Fig. 1, Nos. 5 and 14) arises by tendinous slips from the spinous processes of the six upper dorsal and seventh cervical vertebræ, from the supra-spinous ligament, and from the lower portion of the ligamentum nuchæ. The fleshy fibres are directed upward and outward, and are divided into two portions, an inner and an outer. The *inner* portion is inserted into the mastoid process and into the outer part of the superior curved line of the occipital bone beneath the sterno-mastoid muscle, and is called the *splenius capitis*. The *outer* portion is inserted into the posterior tubercles of the transverse processes of the three upper cervical vertebræ, and is called the *splenius colli*. These muscles are supplied by the external branches of the posterior divisions of the cervical nerves. The action of the splenii muscles aids that of the sterno-mastoid muscles. When the two muscles on both sides contract together, they assist in

holding the head erect. The action of either of them (the two portions working together) is to draw the head and the upper cervical vertebræ toward its own side. When this contraction is permanent it may produce "wry-neck," and may be confounded with the action of the opposite sterno-mastoid muscle, which produces the same effect (page 198).

The *levator anguli scapulæ* (Plate 16, No. 8) arises tendinously from the transverse processes of the four upper cervical vertebræ, the two upper slips being the largest. These unite to form a prismatic muscle which descends along the side of the neck and is inserted into the posterior border of the scapula from the superior angle to the root of the spine. It receives branches from the third and fourth cervical nerves of the deep cervical plexus, and a branch from the fifth cervical nerve. When this muscle is brought into action, it raises the posterior angle of the scapula, as in shrugging the shoulders.

The *cervical portion of the trapezius* muscle covers the preceding muscles. It is superficial (Plate 22, Fig. 1, No. 4) at the back of the neck, and constitutes the lateral bulge on each side of the middle depression over the spines of the cervical vertebræ.

The *trapezius* arises from a variable extent of the inner portion of the superior curved line on the occipital bone, from the ligamentum nuchæ, from the spinous process of the vertebra prominens, and from the spines of all the dorsal vertebræ and their supra-spinous ligaments. Each trapezius muscle is triangular in shape, but the two together form a trapezoid, and between the sixth cervical and the third dorsal vertebra their origin presents a glistening semi-oval aponeurosis, the *speculum rhomboideum.* The fibres of each muscle converge from their extensive vertical origin toward the shoulder, to be inserted upon the scapula exactly corresponding to the origin of the deltoid muscle (Plate 16, No. 10). The upper fibres pass downward and outward, to be inserted into the upper edge of the clavicle, usually upon its outer third, but often extending forward as far as the posterior border of the clavicular portion of the sterno-mastoid muscle; the middle fibres pass transversely outward to the inner border of the acromion process and upper margin of the spine of the scapula; and the lower fibres pass upward and outward and are inserted by a thin tendon

into the tubercle of the spine of the scapula. There is always a layer of loose connective tissue or a mucous bursa interposed between the tendon and the triangular surface at the back of the scapula. The trapezius is supplied by the spinal accessory nerve, and by the deep branches of the cervical plexus. Its nutrient arteries are derived from the superficialis colli and the dorsal branches of the intercostal arteries (Plate 22, Fig. 1, No. 10). When both trapezius muscles act from below they draw the head backward, or one muscle acting in the same manner will turn the head backward to the corresponding side. The whole of each muscle has the power to retract the scapula, and, by rotating it, to raise the shoulder.

Beneath the trapezius and splenius muscles at the back of the neck is the powerful *complexus muscle.* This muscle is broad and thick, and arises usually by seven tendons from the tips of the transverse processes of the three upper dorsal vertebræ and the vertebra prominens and from the articular processes of the sixth, fifth, and fourth cervical vertebræ. It is inserted into the depression between the two occipital curved lines near the median ridge. Very often this muscle presents a transverse tendinous intersection, and a separate fasciculus is sometimes specialized at the spinous border, which, because it has a longitudinal tendon in its centre, is called the *biventer cervicis.* This muscle is separated from its fellow by the *ligamentum nuchæ,* which is practically a continuation upward of the supra-spinous ligament. It consists of fibro-elastic tissue, and extends from the spinous processes of all the cervical vertebræ, except the atlas, to the external occipital protuberance. In a few instances muscular fibres have been found in place of this ligament, but in man it is a rudiment of the strong elastic ligament which enables some of the lower animals to sustain the weight of the head.

At the outer side of the complexus are the *trachelo-mastoid* and *transversalis colli muscles,* which are accessory portions of the longissimus dorsi continued to the head and neck.

The *trachelo-mastoid* muscle arises from the upper five dorsal transverse processes and from the lower four cervical articular processes by tendinous slips which unite to be inserted into the back of the mastoid process beneath the sterno-mastoid and splenius muscles. The *transversalis colli*

PLATE 30.

The lungs inflated, so as to demonstrate the approximation of their edges over the heart, as in full inspiration.

1. The right common carotid artery.
2. The right internal jugular vein.
3. The right scalenus anticus muscle.
4. A rubber tube introduced into the trachea for the purpose of inflating the lungs.
5. The right transversalis colli artery and vein.
6. The right pneumogastric nerve.
7. The sternal end of the right clavicle.
8. The innominate artery.
9. The right subclavian vein and artery.
10. The sternal end of the right first rib.
11. The right innominate vein.
12. The ascending portion of the aorta.
13. The right second rib.
14. The right third rib.
15. The cleft between the upper and lower principal lobes of the right lung.
16. The right lung.
17. The right fourth rib.
18. The right fifth rib.
19. The cleft in the lower portion of the right lung, indicating its division into the so-called middle and inferior lobes.
20. The right sixth rib.
21. The anterior lower border of the right lung (as in full inspiration).
22. The upper surface of the diaphragm.
23. The right seventh rib.
24. The left common carotid artery.
25. The left brachial plexus of nerves.
26. The left internal jugular vein.
27. The trachea at the root of the neck.
28. The left scalenus anticus muscle.
29. The left pneumogastric nerve.
30. The remains of the left coraco-clavicular membrane.
31. The sternal end of the left clavicle.
32. The left subclavian artery.
33. The left subclavian vein.
34. The sternal end of the left first rib.
35. The left innominate vein.
36. The left pneumogastric nerve.
37. The left second rib.
38. The approximation of the edges of the lungs in the median line, covering the root of the heart, as occurs in full inspiration.
39. The left third rib.
40. The upper lobe of the left lung.
41. The left fourth rib.
42. The notch in the anterior edge of the left lung in relation to the apex of the heart.
43. The left fifth rib.
44. The right ventricle of the heart covered with the pericardium.
45. The left sixth rib.
46. The anterior lower border of the left lung (as in full inspiration).
47. The left seventh rib.
48. The left eighth rib.

N. B.—This and the succeeding plates (31, 32, and 33) were taken from a male subject about thirty-two years of age, who died from choking. The lungs were absolutely healthy. The pleuræ were removed in the dissection.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muscle arises by delicate tendons from the six upper dorsal transverse processes, and is inserted by as many tendons into the posterior tubercles of the lower six cervical transverse processes. The last two muscles are supplied by external branches from the posterior divisions of the cervical nerves, the complexus receiving internal branches of these nerves, together with branches from the sub-occipital and great occipital nerves. The action of the trachelo-mastoid and transversalis colli muscles assists the overlying muscles in holding the head erect or in turning it backward to one or the other side according as both pairs of the muscles act together or the individual muscles act severally. The *occipital artery*, after leaving its groove in the temporal bone back of the mastoid process, passes horizontally underneath the sterno-mastoid, splenius, and trachelo-mastoid muscles to the complexus (Plate 22, Fig. 1), upon the outer surface of which it turns upward, and, piercing the attachment of the trapezius, winds tortuously over the occiput, dividing into numerous branches, which supply the tissues of the scalp posteriorly. The point where the occipital artery reaches the scalp (Plate 21, No. 6) is about midway between the external occipital protuberance and the mastoid process, and it also corresponds to the position of the great occipital nerve, with which the vessel is in close relation. The occipital artery furnishes nutrient vessels to the digastric, stylo-hyoid, splenius, trachelo-mastoid, and sterno-mastoid muscles. It also sends a branch to the back of the concha, and one or more *meningeal* branches which enter by the mastoid foramen or through the jugular foramen to supply the neighboring part of the dura mater; but the most important branch is the *princeps cervicis*, which passes downward from the occipital between the complexus and splenius muscles and divides into two branches. One of these is superficial, and, penetrating the splenius, supplies the trapezius and anastomoses with the superficial cervical branch of the transversalis colli; the other takes a deep course between the complexus and semispinalis colli muscles and anastomoses with the vertebral and often with the deep cervical branch from the superior intercostal artery. By means of these anastomoses the collateral circulation is mainly established after ligature of the carotid or subclavian artery.

The deeper muscles beneath the complexus are the prolongations of

the erector spinæ mass. They are of variable development in different subjects, and are interesting because they assist the more superficial muscles in holding the head in the various positions while the body is upright. The *cervicalis ascendens* is the upward continuation of the accessorius muscle: it arises from the angles of the four or five upper ribs, and is inserted by tendons into the posterior tubercles of the transverse processes of the sixth, fifth, and fourth cervical vertebræ. The *spinalis colli* is often absent, but when it exists it connects the spines of the lower cervical vertebræ, like the spinalis dorsi, and is inserted into the spinous process of the axis vertebra. The cervical portion of the *multifidus spinæ* consists of a series of muscular slips extending from the articular processes of the lower four cervical vertebræ, each of which passes obliquely to be inserted into the spinous process of the vertebra above and the contiguous portions of the laminæ.

Besides the above there are the *inter-spinales* and the *inter-transversales*. The former are more pronounced in the neck than they are in the back, and extend between the spinous processes of the lower six cervical vertebræ, while the latter pass between their transverse processes. The anterior portions of the inter-transversales correspond to the intercostal muscles. There are seven in the neck, where they are also most marked, and they are arranged in pairs between the anterior and posterior tubercles of the contiguous vertebræ. All these deeper muscles are supplied with branches from the internal posterior branches of the cervical nerves.

At the very top of the neck there are upon each side various small muscles which are concerned in the movements of the head upon the atlas and axis vertebræ. They are specialized as follows. The *rectus capitis posticus major* is the largest: it arises from the side of the spinous process of the axis, and is inserted into the outer part of the lower curved line on the occipital bone and the rough surface below it. The *rectus capitis posticus minor* is deeper than, and internal to, the major: it arises by a narrow tendon from the posterior tubercle of the atlas, and is inserted by a fan-shaped expansion between the inner portion of the inferior curved line and the foramen magnum. The action of these muscles is to raise the head. The *obliquus capitis inferior* passes from

the spine of the axis to the under surface of the transverse process of the atlas. The *obliquus capitis superior* extends from the upper surface of the transverse process of the atlas, just above the insertion of the former, to the interval between the occipital curved lines. The action of the inferior oblique is to turn the head round to the same side by rotating the atlas upon the axis vertebra. The great occipital nerve supplies it with a branch as it turns round its lower border. The action of the superior oblique is to draw the occiput toward the spine. This muscle and the two recti postici receive branches from the sub-occipital nerve, which is in close relation to them. The so-called *sub-occipital triangle* is formed by the disposition of the two oblique muscles with the rectus capitis posticus major, the obliquus superior being on the outer side, the rectus capitis posticus major on the inner, and the obliquus inferior on the lower. This triangle contains the arch of the atlas vertebra, with the vertebral artery lying in a groove on its upper surface (page 215). The posterior division of the sub-occipital (first spinal nerve) is placed between the artery and the bone.

Beneath the multifidus muscles, upon the laminæ of the cervical vertebræ, there is on both sides of the neck a plexus of large veins, the *cervico-dorsal spinal veins*, which communicate freely with the veins of the vertebral canal through the interlaminar ligaments. The *interlaminar ligaments*, or *ligamenta subflava*, are thick masses of elastic yellow fibrous tissue which fill in the intervals between the arches of the vertebræ. They pass from the upper edge of each vertebra to a rough ridge on the anterior surface of the vertebra above. The ligament upon one side is continuous with its corresponding fellow. In the cervical region these ligaments are thinner than elsewhere, and are directed outwardly to the inner margins of the articular processes. The *interspinous ligaments* in the neck are not markedly developed, and appear like projections of the ligamentum nuchæ between the spinous processes. There is no inter-spinous ligament between the axis and atlas vertebræ, and none between the atlas and the occipital bone. The interlaminar ligament between the atlas and the axis, the *posterior atlanto-axial ligament*, and that below the occipital bone and the atlas, the *posterior occipito-atlantic ligament*,

are deficient in elastic tissue, being composed chiefly of condensed areolar tissue which is closely connected with the dura mater of the spinal cord in front.

The *nerves at the back of the neck* are the posterior divisions of the cervical nerves.

The posterior division of the *first cervical nerve*, or *sub-occipital*, makes its exit from the spinal canal between the arch of the atlas and the vertebral artery, and thence enters the sub-occipital triangle and sends off muscular branches, as already described. The posterior division of the *second cervical nerve*, or *great occipital*, emerges between the arches of the atlas and axis vertebræ. The posterior divisions of the lower six cervical nerves divide into external and internal nerves. Of these the internal are the larger, and those from the second, third, and fourth nerves form the so-called *posterior cervical plexus* beneath the complexus muscle, which after supplying the muscles terminate in the skin over the trapezius. The lower three cervical nerves also give off cutaneous branches.

There are *eight pairs of cervical spinal nerves*, and their origins from the spinal cord can be seen only by removing the posterior segments of the cervical vertebræ (Plate 4, Fig. 2). The removal of these segments exposes the *theca vertebralis*, or cervical portion of the spinal dura mater, through which the spinal nerves pass out, the two roots—anterior (motor) and posterior (sensory)—of each piercing the membrane by separate holes and receiving from it prolongations or sheaths. The *anterior* roots are the smaller, and have no ganglionic enlargement upon them, while the *posterior* roots are larger, and have a ganglion upon each, with the exception sometimes of the posterior root of the first cervical nerve. The two roots of each nerve blend with each other beyond the ganglion, and the *compound trunk* thus formed passes out of the corresponding intervertebral foramen and separates into an *anterior* division to supply the anterior part of the neck, and a *posterior* division to supply the posterior part, each nerve being composed of fibres from both roots. The ganglia are of oval form and proportionate in size to the nerve-trunks to which they contribute, and are generally situated in the intervertebral foramina outside of the dura

mater (Plate 4, Fig. 2). When the first nerve has a ganglion on its posterior root, it is, however, usually within the dura.

The spinal cord presents an enlargement opposite the fifth cervical vertebra, where the nerves are given off which form the brachial plexus on each side. The anatomy of the spinal cord is described with the region of the back in Vol. II.

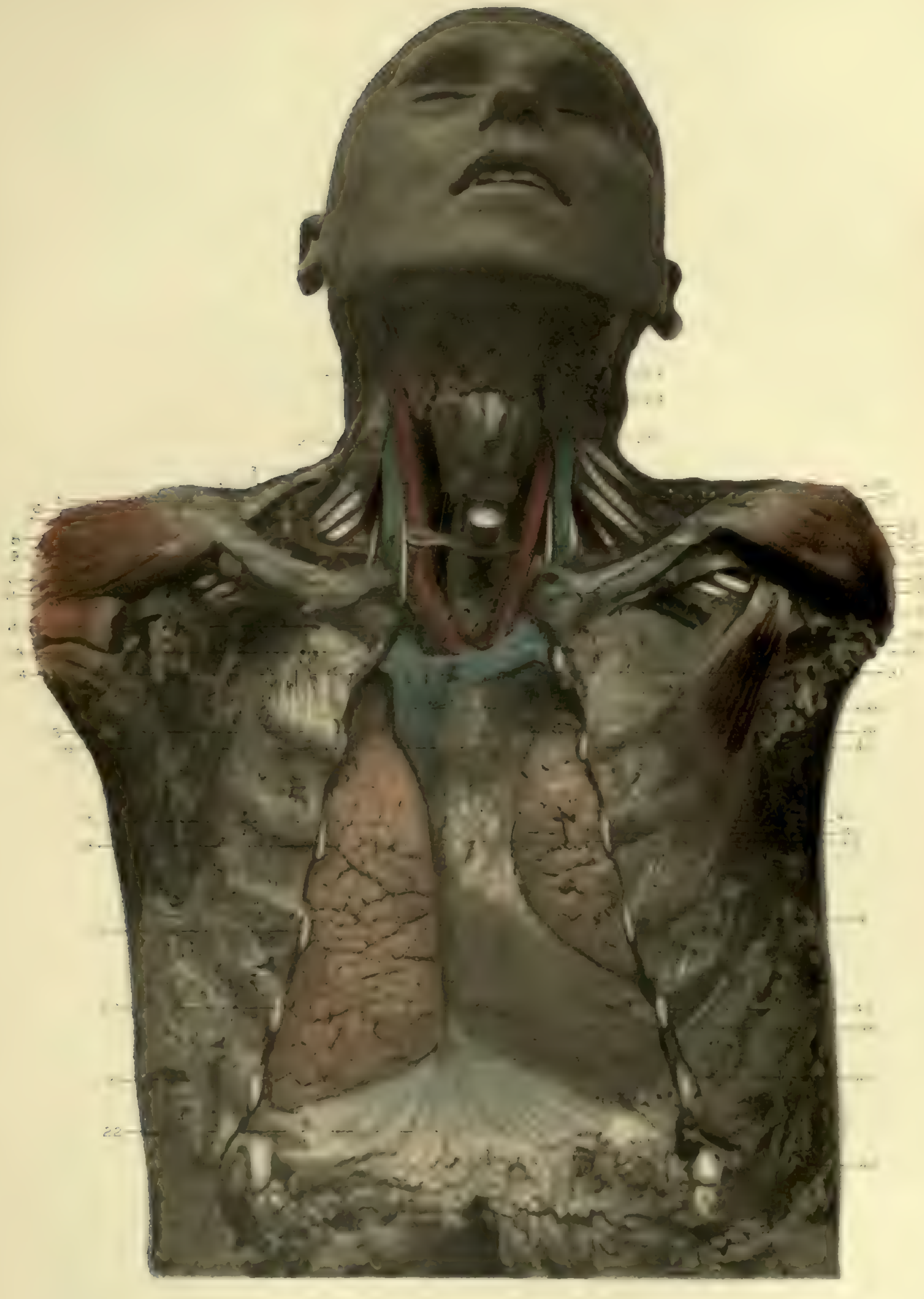
The *vertebral arteries,* after their origins from the subclavian arteries, ascend for a short distance between the longus colli and scalenus anticus muscles on each side, and, entering the foramen in the transverse process of usually the *sixth* cervical vertebra, mount upward through the vertebral foramina above until the interval between the axis and the atlas is reached. Here each artery makes an abrupt curve backward, being accommodated in grooves on the arch of the atlas vertebra within the sub-occipital triangle, and enters the foramen magnum after perforating the posterior occipito-atlantic ligament and the dura mater (Plate 4, Fig. 2, Nos. 9 and 25). Within the skull the two vertebral arteries unite to form the basilar artery, which occupies the anterior median fissure of the pons Varolii (page 46). The cervical branches of the vertebral arteries are small, some going to the deep muscles, and others, the *lateral spinal,* supplying the spinal cord and its membranes in relation to the intervertebral foramina and the contiguous surfaces of the bodies of the vertebræ. The *vertebral veins* commence by tributaries from the muscles in the neighborhood of the foramen magnum, and descend in *front* of the arteries through the vertebral foramina. They are often brought in relation with the lateral sinus by emissary veins through the posterior condyloid foramen on one or the other side.

The characteristic curvature of the cervical portion of the spine is mainly due to the shape of the disks of *intervertebral fibro-cartilage,* which are here thicker in front than behind. These disks, like all the others of the spinal column, consist of outer concentric layers of fibro-cartilage surrounding a pulpy nucleus of elastic tissue. The nucleus is not quite in the centre of each disk, and contains a small irregular-shaped cavity. The fibres at the circumference cross one another, taking an oblique direction from side to side. At the margins of the disks the fibrous layers

PLATE 31.

The relations of the lungs, in moderate distention, to the pericardium, as in ordinary breathing. Also the great vessels and nerves at the root of the neck. The sternum and costal cartilages are removed.

1. The right superior thyroid vessels, and superior laryngeal nerve.
2. The median notch in the thyroid cartilage.
3. The right internal jugular vein.
4. The right common carotid artery.
5. The right scalenus anticus muscle.
6. The median cord of the brachial plexus.
7. The right pneumogastric nerve.
8. The right transversalis colli artery and veins.
9. The right phrenic nerve.
10. The brachial plexus of nerves, and subclavian artery and vein, below the clavicle.
11. The innominate artery.
12. The right recurrent laryngeal nerve.
13. The sternal end of the right first rib.
14. The right innominate vein.
15. The sternal end of the right second rib.
16. The aorta, covered with the pericardium.
17. The right third rib.
18. The right lung.
19. The right fourth rib.
20. The right fifth rib.
21. The right sixth rib.
22. The upper surface of the diaphragm.
23. The body of the hyoid bone.
24. The left superior thyroid vessels, and superior laryngeal nerve.
25. The left internal jugular vein.
26. The left common carotid artery.
27. The left brachial plexus of nerves, above the clavicle.
28. The left phrenic nerve.
29. The left scalenus anticus muscle.
30. The left pneumogastric nerve.
31. The left deltoid muscle.
32. The left brachial plexus, below the clavicle.
33. The sternal end of the left clavicle.
34. The left subclavian artery and vein.
35. The left pectoralis minor muscle.
36. The sternal end of the left first rib.
37. The left innominate vein.
38. The superior vena cava.
39. The position of the pulmonary artery, covered with the pericardium.
40. The left second rib.
41. The upper lobe of the left lung.
42. The left third rib.
43. The position of the right auricle, covered with the pericardium.
44. The left fourth rib.
45. The left fifth rib.
46. The right ventricle of the heart, covered with the pericardium.
47. The left sixth rib.
48. The left seventh rib.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are firmly attached to the contiguous margins of the vertebral bodies above and below. The bodies of the vertebræ and the intervertebral disks are strongly united in front by the *anterior common spinal ligament*, and by a similar band within the spinal canal, called the *posterior common ligament*. The *anterior ligament* consists of several strata, the *outer* being composed of long fibres extending along several vertebræ, and the *inner*, of short fibres from one vertebra to another. This ligament is thicker over the bodies of the vertebræ than the intervertebral disks, and is attached above to the axis in connection with the longus colli muscles. Each joint between the articular processes in the cervical vertebræ is provided with a synovial membrane surrounded with a loose *capsular ligament*, in accordance with the free movement in the neck. For the same reason the joint between the occipital bone and the atlas and axis vertebræ has specialized ligaments. The anterior common ligament is continued upward from the top of the anterior arch of the atlas to the front border of the foramen magnum, as the *anterior occipito-atlantic ligament*, which is thicker at the centre than at either side. The *posterior occipito-atlantic ligament* has been already referred to (page 213). If a section is made of the posterior arches of the two upper vertebræ and the occipital bone, the *ligamentum latum axiale* is exposed. This is a strong fibrous band separated from the posterior common ligament. Beneath the broad axial ligament is the remarkably strong *transverse ligament*, which is stretched across between the internal tuberosities of the atlas back of the odontoid process, a synovial bursa and a thin layer of fibro-cartilage being interposed between the process and the ligament. Some fibres of this ligament pass upward from its centre to be attached to the basilar process, and some downward to the body of the axis. The *occipito-odontoid* or *check ligaments* are placed above the transverse ligament, and extend from the inside of each occipital condyle to the same side of the top of the odontoid process. They are rendered tense by turning the head to one side or the other. A few fibro-cartilaginous fibres pass from the apex of the odontoid process to the front of the foramen magnum, and are called the *suspensory ligament of the axis*. In addition to the above, the articular surfaces of the occiput and atlas are provided with synovial sacs and capsular ligaments. The

cervical curve of the spine is considered as consequent upon the extension of the neck in development, and extends from the atlas to the intervertebral disk between the second and third dorsal vertebræ. The weakest point, not only in the neck but also in the entire column, is between the second and third cervical vertebræ.

The structures in immediate relation to the front of the cervical portion of the spinal column are the prevertebral muscles and fascia (Plate 11, Fig. 1). The *longus colli muscle* consists principally of a *vertical* portion, the fibres of which arise tendinously from the lateral ridges on the bodies of the three upper dorsal and two lower cervical vertebræ external to the common spinous ligament, and are inserted by arching tendons into the bodies of the fourth, third, and second cervical vertebræ, and into the anterior tubercle of the atlas. Besides these there are accessory portions. The *inferior oblique* portion arises with the vertical tendons from the three upper dorsal vertebræ, and is inserted into the transverse processes of the sixth, fifth, and fourth cervical vertebræ. Those fibres which are inserted into the sixth vertebra cover the vertebral artery at its entrance into the foramen in the transverse process of that vertebra. The *superior oblique* portion arises from the transverse processes of the fifth, fourth, third, and sometimes second cervical vertebræ, and is inserted with the vertical portion into the bodies of the upper two vertebræ and the anterior arch of the atlas. The longus colli muscle is supplied by branches from the lower cervical nerves, and the action of the united portions is to bend the cervical vertebræ forward.

The *rectus capitis anticus major muscle* arises from the transverse processes of the fifth, fourth, third, and second cervical vertebræ, and is inserted into the basilar portion of the occipital bone near the pharyngeal spine. Under this muscle there is a much smaller muscle, the *rectus capitis anticus minor,* which arises from the front of the root of the transverse process of the atlas, and is inserted into the basilar process of the occipital bone behind the former muscle. The two *recti antici* are supplied with branches of the anterior division of the sub-occipital nerve, and some filaments from the deep cervical plexus, and their action is to assist in bending the head forward. The *rectus capitis lateralis muscle* extends

from the transverse process of the atlas to the jugular process of the occipital bone, and is in reality the topmost of the series of *inter-transversales muscles* in the cervical region, which extend between the successive transverse processes in front of the exits of the spinal nerves and over the vertebral artery. The laterales are capable of bending the head slightly sideways.

The *cervical portion of the sympathetic nerve* on each side consists of a continuous cord, on which there are three ganglia, situated in front of the transverse processes of the cervical vertebræ. The *superior ganglion* is the largest of the three, and is about opposite the second and third cervical vertebræ, over the rectus capitis anticus major muscle, behind the internal carotid artery, and internal to the pneumogastric nerve (Plate 36, No. 49). It is an elongated, reddish-gray body, generally three centimetres, or about an inch and a quarter, in length. It is sometimes marked by constrictions, and receives externally four communicating branches from the four upper cervical nerves. It sends branches to the upper and lower ganglia of the pneumogastric (page 204), also to the ganglion of Andersch, on the glosso-pharyngeal nerve (page 205), and to the hypoglossal nerve. From the upper portion of the superior ganglion the cord is continued into the carotid canal with the internal carotid artery, to form the carotid sympathetic plexus. Filaments leave the anterior border of the superior ganglion and accompany the branches of the external carotid artery, upon which they form plexuses and are distributed to the territories which they supply. A branch is also sent to the inter-carotic body. The *superior cardiac nerve* arises from the lower part of the superior ganglion, and descends upon the longus colli muscle behind the sheath of the carotid vessels, in close connection with the main sympathetic cord.

The *middle cervical ganglion* is very small and inconstant, and when present is situated opposite the sixth cervical vertebra, near the inferior thyroid artery, and about on a level with the crossing of the omo-hyoid muscle. It receives branches from the adjacent cervical nerves, and gives off thyroid branches and the *middle cardiac nerve,* which descends with the superior cardiac either over or under the subclavian artery to join the cardiac plexus.

The *inferior cervical ganglion* is deeply situated between the transverse process of the vertebra prominens and the neck of the first rib (Plate 36, No. 22). It receives branches from the seventh and eighth cervical nerves, and gives off branches which form the plexuses about the subclavian and vertebral arteries and the *inferior cardiac nerve*, which joins the deep cardiac plexus.

The *scalene muscles* extend from the transverse processes of the cervical vertebræ to the two upper ribs, in the manner of a scalene triangle, on each side, and are comparable to the intercostal muscles both in their attachment and in their function. The *scalenus anticus* arises from the *anterior* tubercles of the transverse processes of the third, fourth, fifth, and sixth cervical vertebræ, and is inserted by a flat tendon at the inner border and upper surface of the first rib (Plates 31, 32, 34, 35, and 36). This muscle is usually described as being inserted into the tubercle (of Lisfranc) on the first rib, and much stress has been laid upon it as an important guide to the adjacent vessels; but, after examining several hundred specimens, the author has the recollection of seeing only four or five upon which any approach to a tubercle was developed. The *scalenus medius* arises from the *posterior* tubercles of the transverse processes of the lower six cervical vertebræ, and is inserted also upon the first rib behind the scalenus anticus. This is the strongest of the three scalene muscles. The *scalenus posticus* arises from the *posterior* tubercles of the transverse processes of the three lowest cervical vertebræ, and is inserted upon the second rib external to its angle. These muscles receive their nerves from the lower cervical nerves, which they surround as they leave their grooves on the upper surfaces of the transverse processes. Their combined action is to raise the thorax, as in deep inspiration, or, being fixed below, they can bend the cervical vertebræ, as in rising from the recumbent position. The scalenus anticus is a guide in distinguishing the position of the important structures with which it is in close relation at the root of the neck. The lower attachment of the scalenus anticus is usually overlapped by the clavicular portion of the sterno-mastoid muscle, but by depressing the shoulder and extending the neck the outer border of the former muscle can be readily felt.

The subclavian artery and the subclavian vein are separated by the costal attachment of the scalenus anticus, as they pass in their respective grooves upon the first rib on their way to and from the axilla. The vein is in front and the artery is behind: the latter can sometimes be felt pulsating over the rib by pressing with the thumb in the supra-clavicular fossa, at the outer border of the sterno-mastoid muscle. In this way also compression of the subclavian artery may be sometimes satisfactorily effected, as is required in amputation at the shoulder. In one instance the author found both the artery and the vein in front of the scalenus anticus; and several cases have been recorded in which the relations of the vessels were reversed, the artery being in front of the vein.

In relation to the scalenus anticus muscle it should be remembered that the *phrenic nerve* (page 207) passes obliquely from the outer to the inner border in front of that muscle, to enter the chest between the subclavian artery and subclavian vein (Plates 25 and 31), and that it is joined on the outer surface of the muscle by a twig from the fifth branch of the cervical plexus as well as by a filament from the sympathetic nerve.

The supra-scapular and transversalis colli arteries (page 233) cross over the lower part of the scalenus anticus, and between it and the scalenus medius and above the subclavian artery are the cords of the brachial plexus of nerves. Its inner border is in close relation with the vertebral artery, which is here covered by the internal jugular vein.

The *structures collected at the root of the neck* (Plate 14, Fig. 2) present a complex arrangement which varies upon both sides, even in the normal condition, in consequence of the mode of distribution of the great aortic branches. The *innominate artery* upon the right side leaves the aorta at the commencement of the transverse portion of the arch behind the middle of the manubrium sterni, opposite the fourth dorsal vertebra, and ascends to the sterno-clavicular joint, behind which it subdivides into the right subclavian and right common carotid arteries. The innominate artery is usually four centimetres, or about an inch and a half, in length, in a well-developed adult, but it is often half an inch longer, and in some cases the vessel ascends above the clavicle close to the trachea before it divides. The innominate sometimes gives off a branch, the *thyroidea ima*

(Plate 43), which ascends to the lower border of the thyroid body along the front of the trachea and compensates for a deficiency in the inferior thyroid artery. In the child, owing to the greater laxity of the connective tissue and the prolongation of the cervical fascia, the innominate artery may be drawn upward into the supra-sternal notch by extending the head and neck backward, but this cannot be done in the adult if the artery is in its normal position. It has been demonstrated on the dead subject (Burns) that if the innominate artery be tied with a ligature the collateral circulation can be established both in the right side of the head and in the right arm, and the operation has been successfully performed on the living subject (Mott); but it is a desperate undertaking, and should not be attempted except as such. The artery lies above the bifurcation of the trachea, and is enveloped in a strong sheath prolonged from the deep cervical fascia, which continues over it to the pericardium. The *two venæ innominatæ*, or *right* and *left brachio-cephalic veins*, converge in front of the innominate artery to empty into the superior vena cava, the right vein descending on the outer side of the artery and the left vein passing across its origin. These veins thus form a triangular space (Plates 31 and 35), in which the artery appears when the loose fascia which connects it to the coat of the *left* innominate vein is removed.

The pneumogastric nerve descends into the thorax between the right innominate vein and the innominate artery at its bifurcation into the right subclavian and common carotid arteries, and in this relation gives off the right recurrent laryngeal nerve, which turns upward under the subclavian or innominate artery, as previously described (page 186). It will be noticed that the great innominate veins, with all their tributaries, occupy a plane anterior to that of their respective arteries, which is the converse of the relation of the arteries and veins below the diaphragm (Plate 42), with the single exception of the *renal* vein. The *innominate veins* are formed respectively by the confluence of the common jugular and subclavian veins of each side. The *right* vein commences behind the right sterno-clavicular joint, and descends a little forward to a point opposite the first right intercostal space, where it is joined at an obtuse angle by the *left* vein, to empty into the superior vena cava. It is about two and a

half centimetres, or an inch, in length, and receives the right internal mammary, superior intercostal, and inferior thyroid veins. The *left* innominate vein is nearly three times the length of the right, being six centimetres, or two and a half inches, as it commences behind the sternal end of the left clavicle and extends across the origins of the left common carotid and innominate arteries. The left vein receives upon its under surface the left internal mammary, thymic, and mediastinal veins, and on its upper surface the left inferior thyroid, vertebral, and deep cervical veins. The tributary veins to both vessels are guarded with single crescentic valves at their orifices. In the young child the left innominate vein is generally above the upper margin of the sternum. Between the innominate vessels and the sternum there is a considerable quantity of adipose and connective tissue, and in the adult the remains of the thymus gland (and in the child, up to the third or fourth year, the gland itself), with numerous veins. These veins form a plexiform net-work, and are associated with the inferior thyroid veins, which occupy the space between the trachea and the top of the sternum and empty into the right and left innominate veins. The presence and proximity of these veins render any operation in this locality extremely hazardous. They are liable to become dilated and engorged from interference with the respiration, as in membranous croup, or under the influence of pressure from a neighboring growth. In a patient from whom the author successfully removed the upper portion of the sternum and adjacent third of the clavicle for osteosarcoma, the venous hemorrhage was appalling, and could be arrested only by sponge pressure.

The *right* and *left common carotid arteries* ascend from the root of the neck by the sides of the trachea, diverging outward from the middle line to their bifurcation opposite the top of the thyroid cartilage (page 201). On a level with the top of the sternum, and three centimetres, or about an inch and a quarter, from the surface, the two carotid arteries are separated from each other by two centimetres, or less than an inch, but at their bifurcation, owing to the breadth of the larynx, they are six centimetres, or two and a half inches, apart (Plates 31, 32, 33, and 42). In consequence of the independent thoracic origin of the *left common carotid artery* from the

PLATE 32.

The relations of the lungs, partially distended (as in tranquil respiration), to the pericardium. Also the vessels and nerves at the root of the neck.

1. The right facial artery.
2. The right facial vein.
3. The right lingual artery.
4. The right thyro-hyoid artery.
5. The right superior laryngeal nerve.
6. The right external carotid artery.
7. The thyroid notch.
8. The thyroid cartilage.
9. The right superior thyroid artery.
10. The right superior thyroid vein.
11. The right common carotid artery.
12. The right scalenus anticus muscle.
13. The right trapezius muscle.
14. The right internal jugular vein.
15. The right brachial plexus of nerves.
16. The right pneumogastric nerve.
17. The right phrenic nerve.
18. The supra-scapular artery and veins.
19. The right recurrent laryngeal nerve.
20. The right deltoid muscle.
21. The brachial plexus of nerves below the clavicle.
22. The right axillary artery.
23. The right axillary vein.
24. The right innominate vein.
25. The sternal end of the right first rib.
26. The superior vena cava.
27. The right phrenic nerve.
28. The sternal end of the right second rib.
29. The upper lobe of the right lung.
30. The right auricle covered with the pericardium.
31. The sternal end of the right third rib.
32. The middle lobe of the right lung.
33. The sternal end of the right fourth rib.
34. The height to which the diaphragm arches on the right side.
35. The sternal end of the right fifth rib.
36. The lower lobe of the right lung.
37. The sternal end of the right sixth rib.
38. The branches of the right phrenic nerve on the diaphragm.
39. The left facial artery.
40. The left facial vein.
41. The left thyro-hyoid artery.
42. The left external carotid artery.
43. The left internal jugular vein.
44. The left superior thyroid artery.
45. The left trapezius muscle.
46. The left crico-thyroid artery.
47. The cricoid cartilage.
48. The left brachial plexus of nerves.
49. The left phrenic nerve.
50. The left scalenus anticus muscle.
51. The left pneumogastric nerve.
52. The left deltoid muscle.
53. The trachea.
54. The left common carotid artery.
55. The left axillary vein.
56. The innominate artery.
57. The left innominate vein.
58. The sternal end of the left first rib.
59. The long thoracic artery.
60. The pectoralis minor muscle.
61. The left phrenic nerve.
62. The root of the heart covered with the pericardium.
63. The sternal end of the left second rib.
64. The upper lobe of the left lung.
65. The sternal end of the left third rib.
66. The sternal end of the left fourth rib.
67. The right ventricle of the heart covered with the pericardium.
68. The sternal end of the left fifth rib.
69. The sternal end of the left sixth rib.
70. The branches of the left phrenic nerve on the diaphragm.
71. The sternal end of the left seventh rib.

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arch of the aorta, it is longer than the *right*, the thoracic portion being equivalent in length to the innominate artery. The thoracic portion of the left common carotid artery is crossed by the left innominate vein, and its under surface is in relation to the trachea, œsophagus, and thoracic duct (Plate 39).

In the neck, between the clavicle and the position of the crossing of the omo-hyoid muscle the relations of the two carotids are almost identical. The *right* artery is usually a little nearer the surface than the left, and its calibre is larger. The *right* and *left common jugular veins* occupy separate compartments of the general sheaths on the outer sides of their companion arteries. As they approach their termination in the innominate veins they overlap the arteries, and on the left side this is more especially so than on the right (Plates 33 and 42), because of the inclination of the large veins from the left to the right side to reach the venous side of the heart. The calibre of the right common jugular usually exceeds that of the left, and they are both provided with double valves about three centimetres, or an inch and a quarter, above their terminations.

The *right* and *left pneumogastric nerves* ascend also in separate compartments of the sheath *posterior* to the septa between the artery and the vein, but somewhat nearer the latter. The position of the carotid vessels, on each side, may be indicated by drawing a line from the top of the sternal end of the clavicle to the parotid gland between the mastoid process and the angle of the lower jaw. As the sterno-mastoid muscle is attached to the anterior surface of the top of the sternum, with its fibres interlacing with those of the sternal portion of its fellow muscle (Plates 23 and 24), it completely covers the line of the carotid vessels, which in reality corresponds to the space between the sternal and clavicular attachments of the sterno-mastoid muscle (page 197). Between the sheath of the vessels and the sterno-mastoid muscles at the root of the neck there are also the sternal attachments of the sterno-hyoid and sterno-thyroid muscles, and between the latter muscles and the sheath are the intricate thyroid veins, and sometimes the external jugular vein passing into the internal jugular to empty conjointly into the subclavian (Plate 21).

The sheath of the carotid vessels is separated posteriorly from the bodies

of the lower cervical vertebræ by the longus colli and rectus capitus anticus muscles. It is in close relation with the sympathetic nerve cord, and separated from the vertebral artery by the inferior thyroid artery, which winds upward and inward from the subclavian to the thyroid body. To the inner side are the trachea, the larynx, and a lobe of the thyroid body. The œsophagus inclines to the left of the middle line at the root of the neck, so that it is in closer relation to the left carotid sheath. The recurrent laryngeal nerve on both sides ascends to the larynx between the trachea and the œsophagus, but is separated from the carotid sheath by considerable cellular tissue (Plate 24, Fig. 2).

In the operation for applying a ligature upon the carotid artery it is essential to avoid as far as possible interfering with the cellular investment of the sheath and its attachment to the reflections of the deep cervical fascia (page 195). In order to reach the artery the head should be turned to the opposite side over a pillow, so as to bring into relief the anterior border of the sterno-mastoid muscle, along which an incision from three to four inches in length should be made through the skin, superficial fascia, and platysma muscle so as to intersect the line of crossing of the omo-hyoid muscle at the level of the cricoid cartilage. The carotid sheath is immediately under the omo-hyoid, and this muscle may be cut through, or the sheath can be opened above or below it as required. A finger pressed upon the vein at the root of the neck will cause it to distend and reveal its precise relation. The sheath should be opened on the tracheal side, and it is well to raise the head and to turn it to the same side before passing the artery needle, so as to relax the tissues and avoid including or injuring any of the adjacent structures. The descendens hypoglossi nerve is usually seen upon the sheath, and the sterno-mastoid branch from the superior thyroid artery crosses it near the omo-hyoid muscle. The thyroid veins are numerous over the sheath at the root of the neck; and if it is necessary to tie the artery in that locality, they must first be secured with a double ligature and severed. Upon the left side the operation low down is attended with so much difficulty that it is well to divide the sternal attachment of the sterno-mastoid muscle, which will render the vessel more accessible.

After ligation of the common carotid artery the collateral circulation is established through the anastomoses of the branches of the external and internal carotid arteries of the opposite side with the branches of the ligatured side, in which the blood-current is reversed, and between the vertebral and posterior communicating, the inferior and superior thyroids, and the profunda and princeps cervicis, of the same side.

The *deep cervical lymphatic glands* (or *glandulæ concatenatæ*) form a chain extending from the base of the skull to the root of the neck embedded in the connective tissue which surrounds the great vessels. Some of these glands are directly over the sheath of the common carotid, and others lie between it and the bodies of the cervical vertebræ, so that when they become diseased they are often so adherent to the adjoining structures that their removal is extremely hazardous. These glands are continuous with the thoracic and axillary glands. They are most numerous in the neighborhood of the bifurcation of the common carotid artery by the side of the pharynx, as they receive here the lymphatic vessels from all parts of the head and neck. The cervical lymphatic vessels unite at the inner border of the scalenus anticus muscle on both sides, so as to form the *jugular lymphatic trunks.* Upon the *right side* the trunk empties into the *right lymphatic duct,* which is about twelve millimetres, or half an inch, in length, and terminates at the junction of the common jugular and subclavian veins, and on the *left side* the trunk generally empties into the *thoracic duct* (page 318), and sometimes, by a separate orifice, directly into the angle of junction of the left common jugular and subclavian veins (Plate 20).

The subclavian arteries differ not only in their origins but in their relations upon the two sides of the root of the neck (Plates 33, 35, and 39). Each of them pursues an arching course to pass behind the scalenus anticus muscle (page 221), which divides the vessel into three portions,—the first or *pectoral* portion being between its origin and the inner border of the scalenus anticus, the second or *muscular* portion that which is behind it, and the third or *cervical* portion that which is between the outer border of the muscle and the lower border of the first rib, whence the artery continues as the axillary.

The *right subclavian artery* ordinarily leaves the innominate behind the sterno-clavicular joint, and its *first portion* is very deeply placed as it passes upward and outward to the inner border of the scalenus anticus. Any change in the position of the bifurcation of the innominate artery will of course affect the point of origin of this artery. Besides the superficial coverings, it has over it the insertions of the presternal muscles (Plate 23) and a layer of deep fascia which is projected from the inner border of the scalenus anticus muscle. Under this fascia it is crossed by the common jugular and vertebral veins (Plate 21), by the pneumogastric and phrenic nerves (Plates 34 and 35), and by the superior cardiac sympathetic nerves. Behind the artery are the recurrent and sympathetic nerves (Plate 36) upon the longus colli muscle and the transverse process of the first dorsal vertebra. It is here, also, in close proximity to the apex of the right lung covered with its pleura (Plate 39). The subclavian vein lies below the artery, under cover of the clavicle. Three branches are given off from the first portion of the subclavian artery,—*i.e.*, from its under surface the internal mammary (page 257), and from its upper surface the vertebral (page 232) and the thyroid axis (page 232).

The *left subclavian artery* commences within the thorax by an independent origin from the arch of the aorta, and its first portion is consequently longer than that of the right. Its calibre is less, and it is also deeper. Within the thorax the first portion is crowded by the apex of the left lung within its pleura. It is covered by the sternal end of the first rib, by the sterno-clavicular joint, and by the left subclavian vein on its way to join the jugular vein to form the left innominate vein. Between the vein and the artery in this locality the phrenic nerve descends. Behind the artery, and internal to it, are the trachea, the œsophagus, the left recurrent laryngeal nerve, the inferior cervical ganglion of the sympathetic, and the thoracic duct (Plates 36 and 39).

Above the clavicle the first portion of the left subclavian artery corresponds very nearly in its relations to those on the right side, and its branches are similarly disposed. The *second portions* of both the right and left arteries very closely resemble each other as they pass between the

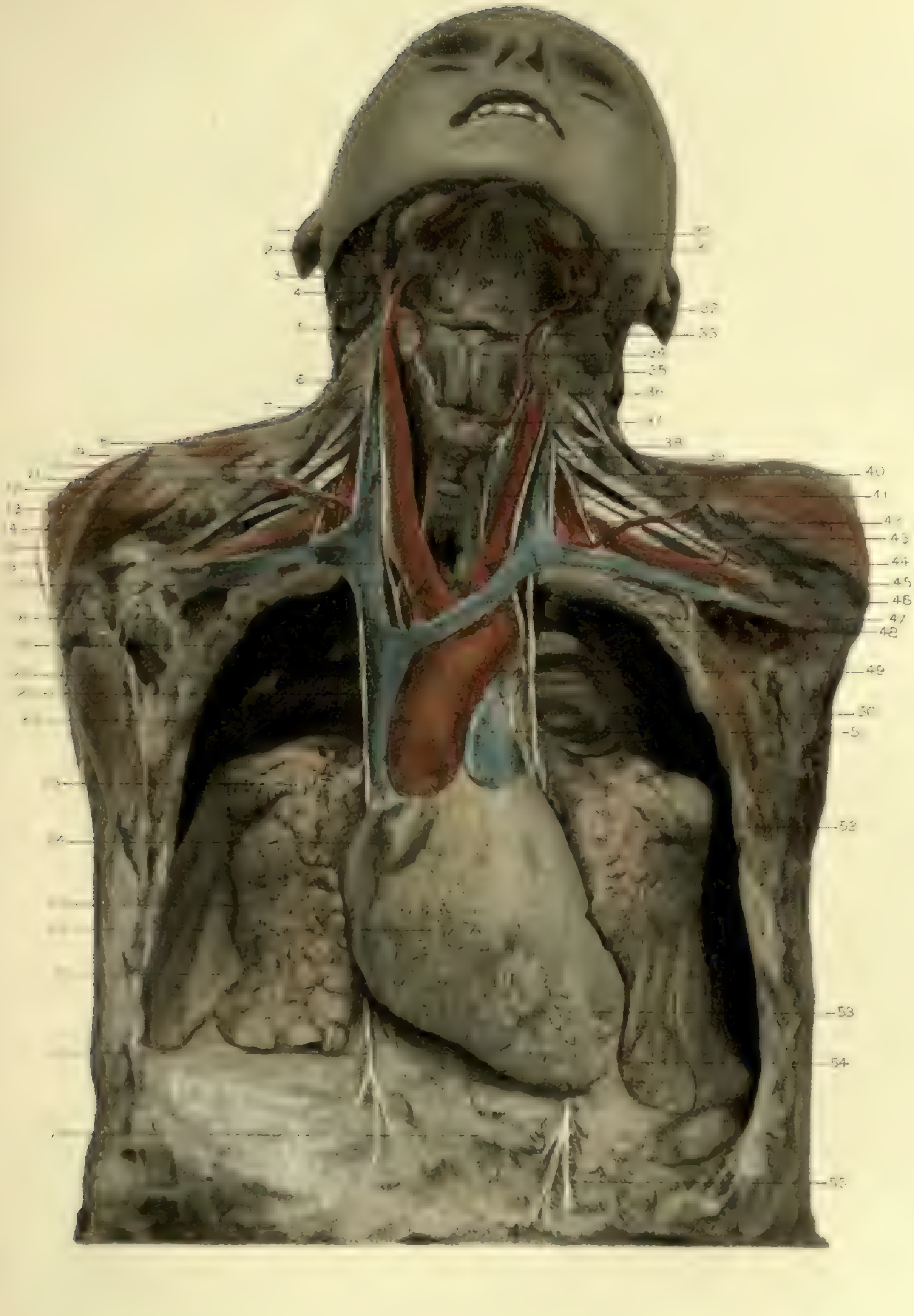
scalenus anticus and scalenus medius muscles over the first rib, the only difference being in the height to which the artery ascends above the clavicle, which in some cases is as high as four centimetres, or an inch and a half. The right subclavian usually arches higher than the left (Plate 35). The phrenic nerve descends across the scalenus anticus muscle, and at its anterior border passes between the artery and the vein. The superior intercostal artery is the only branch given off from the subclavian behind the scalenus anticus.

The *third portions of both subclavian arteries* also resemble each other in their relations. Here the vessel is more superficial as it passes downward over the first rib. It occupies the supra-clavicular triangle, formed by the sterno-mastoid and omo-hyoid muscles and the clavicle; but it should be remembered that the dimensions of this triangle may be encroached upon by the approximation of the sterno-mastoid and trapezius muscles (page 207). As this portion of the artery is most readily exposed, and therefore most easily ligatured, it deserves special attention. Besides the superficial coverings in this locality, there is the double layer of deep fascia, consisting of the expansion from the omo-hyoid to the clavicle and the underlying expansion from the scalenus anticus. Within the superficial fascia the supra-clavicular nerves, the lower end of the external jugular vein, and the transverse cervical and supra-scapular veins cross this space (Plates 18 and 19). In the ordinary position of the arm the clavicle and subclavius muscle and the supra-scapular vessels lie directly over this portion of the subclavian artery, but by turning the head and neck to the opposite side and depressing the shoulder the *axillary* artery may be drawn upward and made to take its place. The artery rests directly in a groove upon the first rib, and the outer border of the scalenus anticus muscle is a direct guide to it (page 220). The subclavian vein is below and on a plane anterior to it, under cover of the clavicle. The cords of the brachial plexus of nerves and the posterior portion of the omo-hyoid muscle are placed obliquely above the artery. The supra-scapular artery usually arises from the third portion of the subclavian, although occasionally it is derived from the thyroid axis at the inner border of the scalenus anticus muscle.

PLATE 33.

The relations of the lungs, when completely collapsed, to the heart. Also the deeper relations of the vessels and nerves at the root of the neck. The pericardium is removed, and the ribs sawn through at their middle to give a better view into the cavity of the thorax. The clavicles are also removed.

1. The right facial artery and vein.
2. The right digastric muscle.
3. The right lingual artery.
4. The right superior laryngeal nerve.
5. The right superior thyroid artery.
6. The right common carotid artery.
7. The right internal jugular vein.
8. The right pneumogastric nerve.
9. The right phrenic nerve.
10. The right brachial plexus of nerves.
11. The right scalenus anticus muscle.
12. The right supra-scapular artery and veins.
13. The right subclavian artery.
14. The origin of the subclavian artery from the innominate artery.
15. The right subclavian vein.
16. The innominate artery.
17. The right recurrent laryngeal nerve, winding under the innominate artery.
18. The right innominate vein.
19. The back of the upper part of the thoracic cavity.
20. The superior vena cava.
21. The right phrenic nerve.
22. The ascending portion of the aorta.
23. The upper lobe of the right lung.
24. The right auricle of the heart.
25. The middle lobe of the right lung.
26. The position of the tricuspid valve.
27. The lower lobe of the right lung.
28. The branches of the right phrenic nerve on the upper surface of the diaphragm.
29. The diaphragm.
30. The left facial artery and vein.
31. The left digastric muscle.
32. The body of the hyoid bone.
33. The thyro-hyoid membrane.
34. The thyroid notch.
35. The left superior laryngeal nerve.
36. The left superior thyroid vein and artery.
37. The crico-thyroid membrane, and the crico-thyroid artery.
38. The cricoid cartilage.
39. The left internal jugular vein.
40. The left common carotid artery.
41. The left recurrent laryngeal nerve.
42. The left scalenus anticus muscle.
43. The left brachial plexus of nerves.
44. The left subclavian artery.
45. The left subclavian vein.
46. The left innominate vein.
47. The left pneumogastric nerve giving off its recurrent branch to pass under the aorta.
48. The back of the upper part of the thoracic cavity.
49. The transverse portion of the arch of the aorta.
50. The left phrenic nerve.
51. The pulmonary artery.
52. The upper lobe of the left lung.
53. The right ventricle of the heart.
54. The lower lobe of the left lung.
55. The branches of the left phrenic nerve on the upper surface of the diaphragm.



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The *subclavian vein*, upon either side, does not arch upward like its companion artery, but takes nearly a straight course to join with the common jugular in forming the corresponding innominate vein. It extends from the lower border of the first rib to a point between the insertion of the scalenus anticus and the sterno-clavicular joint. The phrenic and pneumogastric nerves descend between it and the artery upon both sides of the neck, and it receives its blood through the anterior and external jugular veins. Before its junction with the common jugular it is guarded with a pair of valves. It should be noted that throughout its course the subclavian vein is placed on a lower plane than, and in front of, the artery. The sheath over the subclavian vessels is attached to the back of the clavicle, and, as the vein is more firmly enveloped by it than the artery, it follows the movements of that bone. This intimate relation of the vein to the clavicle renders it liable to injury in fractures of that bone. The operation for tying the subclavian artery is a difficult task, even upon the dead subject with the parts in their normal positions. It is naturally more so upon the living, and not only is a practical knowledge of the anatomy requisite, but also a knowledge of the possible deviations which attend the structural changes in consequence of aneurism or other tumor involving this region.

In *ligation of the subclavian artery* in the third or outer part of its course the patient's head should be turned back, the shoulders raised, and the arm pulled down to the utmost, so as to lower the clavicle. The integument should be drawn downward, and an incision several inches long should be made directly upon the clavicle through the superficial coverings. If the trapezius and sterno-mastoid muscles overlap the supra-clavicular space they must be cut and turned aside. In this incision care must be taken not to wound the external jugular vein, and, as the supra-scapular veins are often in the way, they may require a double ligature and section. The deep fascia can be opened by following the external jugular vein as it pierces it. Much time is often lost through mistaking the cellular space above the deep fascia for that below it. In the depths of the latter the artery in question is situated. In more than one instance the lower cord of the brachial plexus has been mistaken for the artery, and on several

occasions tied; but this is not likely to happen if before securing the ligature the arm is raised and rotated, so as to relax the parts, when they can be better recognized. The impression conveyed to the finger by pressing over the first rib should never be relied on. The operator does not usually see the vein. It is out of the way, below the clavicle. In the deeper cellular space there is generally a quantity of fat, with some lymphatic glands, which when enlarged offer additional embarrassment to the operation. The collateral circulation after the artery has been tied in its outer portion is maintained by the occluded branches of the axillary artery drawing the blood from their anastomoses with the superior intercostal, upper aortic, intercostal, and internal mammary arteries, assisted by the communications between the dorsalis scapulæ and the supra-scapular and posterior scapular arteries.

The *vertebral artery* arises from the upper and posterior surface of the first portion of the subclavian. It ascends behind the common jugular vein, and runs between the scalenus anticus and longus colli muscles until it enters the vertebral foramen in the transverse process of the *sixth* cervical vertebra. On the way it is crossed by the inferior thyroid artery, and on the *left side* by the thoracic duct. The sympathetic nerve cord is in close relation to it, and some delicate nerves from the inferior cervical ganglion pass along with it, and others pass across, to blend with the cords of the brachial plexus. After entering the transverse process of the sixth vertebra it continues up through the corresponding foramina in the transverse processes of the vertebræ above until it arrives at the atlas in the sub-occipital triangle (Plate 4, Fig. 2), where, after it rises through the foramen in the transverse process, it turns backward round the condyle of the occipital bone to penetrate the posterior occipito-atlantic ligament and to enter the sub-dural space within the foramen magnum. Within the cranium the vertebral artery passes between the hypoglossal nerve and the anterior root of the first cervical nerve and ascends upon the basilar process to join with its fellow (page 22) and form the basilar artery (Plate 5, Fig. 3).

The *thyroid axis* is a short trunk arising from the first portion of the subclavian at the inner border of the scalenus anticus muscle. It usually

divides into three branches, the inferior thyroid, the transversalis colli, and the supra-scapular. The *inferior thyroid* artery ascends tortuously across the vertebral artery, the recurrent laryngeal nerve, and the longus colli muscle to the corresponding lobe of the thyroid body. The middle cervical ganglion of the sympathetic nerve is very close to it as it passes beneath the sheath of the carotid vessels. The inferior thyroid sends off branches to the pharynx, œsophagus, trachea, and the anterior mediastinal glands, and the little inferior laryngeal artery which accompanies the recurrent laryngeal nerve. Within the thyroid body it breaks up into terminal branches which anastomose freely with those of the other thyroid arteries. The *transversalis colli artery* usually arises from the axis and passes over the scalene muscles and the brachial plexus to reach the upper angle of the scapula, where it supplies the adjacent muscles. Its veins are in close relation with it and empty their blood into the external jugular. The transversalis colli often gives off the *superficial cervical* artery, which passes upward along the border of the trapezius muscle (Plate 25) and anastomoses with the descending branch of the occipital artery. It is accompanied by two venæ comites, which join the transverse veins. The *supra-scapular artery* arises sometimes from the thyroid axis, sometimes independently from the third portion of the subclavian artery (page 229). It passes behind the clavicle, separated from the subclavian artery by the reflection of the deep cervical fascia from the omo-hyoid muscle, and on reaching the scapula it enters the supraspinous fossa. It then passes over the supra-scapular ligament and eventually terminates in the infra-spinous fossa. In its course it sends branches to the neighboring muscles, to the clavicle, to the acromion and body of the scapula, and to the shoulder-joint. This vessel is accompanied by two veins, which are provided with valves at their termination in the external jugular or subclavian veins.

The thyroid body is the very vascular glandular organ which is situated in the neck over the front and sides of the upper part of the trachea, extending upward on each side of the larynx. It consists of two ovoid *lateral lobes*, united near their lower borders by a median transverse portion, the *isthmus*. It is of a reddish-brown color, and weighs in the

adult about two ounces. Each lobe extends from the fifth or sixth ring of the trachea below to the side of the thyroid cartilage above, which is embraced by the narrower end. Each lobe is five centimetres, or about two inches, in length, by three centimetres, or an inch and a quarter, in breadth. The anterior surface is convex, and covered by the infra-hyoid, sterno-hyoid, sterno-thyroid, and omo-hyoid muscles (Plates 23, 24, and 25), and is overlapped at the sides by the anterior borders of the sterno-mastoid muscles. The posterior surface is adapted to and closely adherent to the parts of the trachea, larynx, and œsophagus over which it lies. The carotid sheath is usually in contact with the external border of the lobe on each side, but very often it is embraced, particularly on the *right* side, by the glandular structure.

The isthmus is variable in size, shape, and position, and usually crosses over the second and third rings of the trachea, being firmly attached by a band of the deep cervical fascia, besides the general investment which connects the thyroid body to the sides of the trachea and to the cricoid and thyroid cartilages. In consequence of this intimate association the organ rises and falls with the larynx in swallowing, and thus a valuable means is afforded of distinguishing the character of any enlargement of its lobes. Very often there is an accessory *pyramidal middle lobe* which extends upward from the junction of the isthmus with the left lobe to be attached to the thyro-hyoid membrane by a fascial band. This may sometimes be covered by a separate slip from the sterno-hyoid muscle, called the *levator corporis thyroidei.*

The thyroid body varies in size in different individuals and at different periods of life. It is relatively larger in the child than in the adult, and in the female than in the male. In children the isthmus is usually very insignificant. The function of the thyroid body is unknown, but it is supposed to be in some way a blood-forming organ and to regulate the production of mucin. Each lobe consists of many irregular lobules, held together by areolar-tissue septa which are inflected from the external glandular investment. In these septa are the branchings of the vessels, surrounded not unfrequently with a colloid substance. The lobules are composed of a great number of closed follicles, the epithelial lining of

which secretes a serous fluid in the child. In the adult the lining wall degenerates and colloid matter takes the place of the earlier limpid fluid. There are fine sympathetic nerve filaments which accompany the vessels throughout the glandular structure; and there are numerous lymphatic vessels which commence in lymph-spaces in the interlobular septa and terminate in the lymphatic ducts upon each side of the neck. There is no proper duct to the thyroid body itself. The *arteries* which supply the thyroid body are remarkable for their number, size, and free inosculation. The *superior thyroid arteries* (page 203) arise from the external carotid arteries just below the greater cornua of the thyroid cartilage, and curve downward beneath the infra-hyoid muscles to the upper and front surface of the thyroid body (Plate 24). The *inferior thyroid arteries* arise from the thyroid axis of the subclavian arteries (page 233) and ascend tortuously to the under surface of the thyroid body. Occasionally there is a middle thyroid artery, the *thyroidea ima,* which arises either from the arch of the aorta or from the innominate artery and ascends in front of the trachea to the isthmus. The *thyroid veins* are also remarkably large, and form a plexus upon the lobes of the thyroid body. The *superior* and *middle thyroid veins* upon each side empty into the internal jugular. The *inferior thyroid veins* communicate freely with each other over the trachea in the anterior part of the root of the neck, and terminate in the innominate veins. The relations of the thyroid body to the great vessels and nerves of the neck explain many of the symptoms produced by the hypertrophied condition of any portion of it, known as "bronchocele."

The *trachea* in the neck is covered anteriorly by the sterno-hyoid and sterno-thyroid muscles (Plate 23, Fig. 2). The *sterno-hyoid muscles* are thin fleshy bands of parallel fibres beneath the skin, which arise on each side from the posterior surface of the sterno-clavicular joint and the contiguous portions of the clavicle and manubrium sterni. They ascend and converge to be inserted tendinously into the lower border of the body of the hyoid bone. The *sterno-thyroid muscles* arise from the posterior surface of the manubrium sterni, internal to the sterno-hyoid muscles, and from the cartilage of the first rib on each side, and ascend like two muscular ribbons, diverging a little from each other to be inserted into the oblique

lines of the alæ of the thyroid cartilage. Occasionally these muscles present tendinous intersections. The *thyro-hyoid muscles* are continuations upward of the sterno-thyroid muscles, and are variable in their degree of separation from them. They are somewhat broader than the sterno-hyoid, and project laterally beneath the attachments of the omo-hyoid muscles. These muscles are all brought into action in forced inspiration. The sterno-hyoid aids the omo-hyoid in depressing the hyoid bone. The thyro-hyoid elevates the thyroid cartilage, while it is depressed by the sterno-thyroid. These muscles are innervated by the communicating loop from the descendens hypoglossi nerve (Plate 27). In the middle line the fascial sheaths of the sterno-thyroid and sterno-hyoid muscles blend and form the *linea alba cervicalis,* which can be readily distinguished after incision through the integument (Plate 23.)

The trachea is the cartilaginous and membranous portion of the windpipe which commences at the cricoid cartilage of the larynx opposite the fifth cervical vertebra (page 177) and extends medially downward to about the body of the fourth dorsal vertebra, where it divides into the right and left bronchi (page 268). It is situated partly in the neck, and partly within the superior mediastinum of the thorax (page 260). The length of the trachea in the adult is from ten to eleven and a half centimetres, or from four to four and a half inches, and its diameter is about nineteen millimetres, or three-fourths of an inch, from before backward, and a little more than that from side to side. The dimensions vary with the age and development of the individual, and in the female the trachea is smaller than in the male. In a general way the calibre may be said to correspond to the size of the patient's forefinger. It is a cylindrical tube flattened behind, so that upon section it appears shaped like the letter **D** (Plate 26, Fig. 2, No. 7). It is composed of a series of incomplete cartilaginous rings, from sixteen to twenty in number, which extend round the anterior two-thirds of its circumference. At the posterior deficiency in the rings, where the trachea is in relation to the œsophagus, the tube is completed by a fibro-muscular membrane, in consequence of which its calibre can be increased or enlarged. The muscular tissue consists of layers of longitudinal and transverse fibres. The spaces between the rings are filled

up with the fibrous membrane, in which there is an additional development of elastic tissue. The hoops of the rings are generally parallel with one another across the front of the tube, but their extremities offer great diversity in conformation. Sometimes they fork, alternating upon the two sides, and sometimes the ends of the adjacent rings are united. The last ring is peculiar, and usually is modified by being prolonged in front in a V-shaped piece so as to conform with the first rings of the two bronchi. The top ring is always broader than the rest, and is strongly connected by fibrous tissue with the lower border of the cricoid cartilage, with which it is sometimes blended. The tracheal cartilages rarely ossify, as they are non-vascular. They are invested with a dense perichondrium which closely adheres to the entire tube. The mucous lining of this portion of the air-passage is smooth and of pinkish color, although it is but slightly vascular. Within the sub-mucous layer are the blood-vessels, lymphatics, and nerves, together with a number of small racemose mucous glands, the *tracheal glands*. These are situated mostly in the posterior membranous wall and along the borders of the rings, and their ducts convey their secretion to the inner lining. In bronchitis they are the sources of the abundant secretion. The tracheal arteries are supplied by the inferior thyroid arteries (page 233) and run longitudinally downward to terminate in capillary plexuses. The nerves are derived from the pneumogastrics and their recurrent branches. The trachea is surrounded by a quantity of loose connective tissue, especially in children, which allows of its free mobility. This mobility of the trachea is one of the greatest obstacles to the satisfactory performance of tracheotomy, as it is essential to fix the trachea in the middle line, which here, as elsewhere in the body, is regarded surgically as the line of safety, owing to the feeble anastomosis of the vessels from side to side.

In the performance of the *operation of tracheotomy*, the patient's head should be extended straight backward, with the shoulders elevated over a firm pillow, so as to bring the trachea into relief and to steady it as much as possible. The landmarks, consisting of the thyroid notch, the hoop of the cricoid cartilage, and the top of the sternum, are clearly noticeable. The upper rings of the trachea cannot be detected through the

PLATE 34.

Preparation to show the relations of the heart, within the pericardium.

1. The thyro-hyoid membrane.
2. The thyroid notch.
3. The right thyro-hyoid muscle.
4. The right superior thyroid artery.
5. The right superior laryngeal nerve.
6. The right crico-thyroid muscle, and crico-thyroid artery.
7. The right pneumogastric nerve.
8. The right common carotid artery.
9. The right supra-scapular artery.
10. The right scalenus anticus muscle.
11. The right phrenic nerve.
12. The right brachial plexus of nerves.
13. The right subclavian artery.
14. The right first rib.
15. The right pneumogastric nerve, passing behind the right innominate vein.
16. The innominate artery.
17. The right innominate vein.
18. The upper lobe of the right lung, drawn aside.
19. The superior vena cava.
20. The right phrenic nerve.
21. The middle lobe of the right lung, drawn aside.
22. The position of the right auricle, covered with the pericardium.
23. The lower lobe of the right lung.
24. The right ventricle of the heart within the pericardium.
25. The left superior thyroid artery.
26. The left thyro-hyoid muscle.
27. The crico-thyroid membrane.
28. The cricoid cartilage.
29. The left internal jugular vein.
30. The left common carotid artery.
31. The left pneumogastric nerve.
32. The left brachial plexus of nerves.
33. The left recurrent laryngeal nerve.
34. The left scalenus anticus muscle.
35. The trachea.
36. The left subclavian artery.
37. The left subclavian vein.
38. The left phrenic nerve.
39. The left innominate vein.
40. The upper lobe of the left lung, drawn aside.
41. The position of the pulmonary artery within the pericardium.
42. The left lung, drawn aside.
43. The left phrenic nerve.
44. The apex of the heart within the pericardium.
45. The lower portion of the lower lobe of the left lung, drawn aside.
46. The position where the pericardium blends with the central tendon of the diaphragm.

N. B.—The ribs are cut away so as to give an unrestricted view.

integument, except in very thin subjects. The isthmus of the thyroid body crosses over the second and third tracheal rings, and is usually very closely bound down to them. It should be remembered that the crico-thyroid artery passes over the top of the crico-thyroid membrane (page 184), that occasionally the anterior jugular vein occupies the middle line (page 192), and that the inferior thyroid veins always intercommunicate over the trachea at the root of the neck (page 235). These anatomical facts indicate the isthmus of the thyroid body as the point above which or below which the operation offers special features of interest. In all cases it is well to make the incision through the superficial tissues free; and it should be kept absolutely in the middle line. It should divide the skin over the position of the isthmus of the thyroid body, when the anterior jugular vein, if present, will be recognized, and the white aponeurotic line between the sterno-hyoid and sterno-thyroid muscles will be exposed. The surface of the crico-thyroid membrane should be carefully examined for the presence of any transverse vessel,—the crico-thyroid or superior thyroid,—and traction should be made upon the isthmus to see whether it can be drawn upward or downward. If it cannot be displaced it may be cut through upon a director, and, if necessary, between a double ligature. When the trachea is sufficiently exposed, a tenaculum should be inserted to steady it, and the upper rings cut by plunging into them the point of the knife to the extent of half an inch, so as fully to open the mucous lining. This precaution is necessary when there is a false membrane, so that the canulated metal tube when inserted may not pass between it and the tracheal wall. It is not safe to make the plunge with the knife deeper than half an inch, on account of the danger of wounding the œsophagus. It is noticeable that when air enters the lungs through the tracheal wound the engorgement of the tributary veins subsides in consequence of the relief afforded to the heart, which is thus enabled to pump out the venous blood from its right side. Below the isthmus of the thyroid body the trachea becomes deeper as it descends behind the sternum (page 190), which adds greatly to the difficulty of opening it in this situation. In little children the neck is usually very fat, and at the root of the neck, besides the intricate inferior thyroid veins, the *left* innominate vein, and

even the innominate artery, may be drawn upward above the margin of the manubrium sterni, in consequence of the comparatively greater laxity of the connective tissue. The upper portion of the thymus gland is also often in the way. In the adult, however, unless there is an unusual origin for the innominate artery, it can hardly be made to mount so high as the supra-sternal notch by stretching the neck, as already stated (page 222). In operating below the isthmus the inferior thyroid veins should never be forgotten, and the knife should be introduced with the back toward the sternum, to avoid the thymus gland and other structures in that situation.

THE REGION OF THE THORAX.

The landmarks of this region are so obscured by the superficial and external structures that they are not easily recognized without particular knowledge of the component parts in their several localities. They are of the greatest importance, on account of their medical application in the physical examination of the chest as relates to diagnosis by auscultation or percussion in affections of the thoracic organs. Attention will therefore be first drawn to the general construction of the thorax, and then to its principal features in detail, before considering its topographical relations.

The skeleton of the thorax (Plate 28) is composed of the dorsal vertebræ, the ribs and costal cartilages, and the sternum, so arranged as to form a conical, movable framework, which gives attachment to the muscles of respiration, and affords protection to the heart and the lungs. The method of the articulation of the ribs with the dorsal vertebræ behind, and with the sternum through their cartilages in front, is one of the most ingenious pieces of mechanism in nature, which not only permits the unceasing momentary alterations in capacity of the thoracic cavity during respiration, but also fulfils the function of support and protection.

The *ribs* are twelve pairs of flattened, bony hoops, which are attached to the spinal column between the neck and the loins, and so arranged that they project anteriorly and describe a series of arches which increase in length to the seventh and in obliquity to the ninth from above downward. The obliquity of the ribs is so great that the sternal end of any rib is on

a level with the vertebral end considerably below it in numerical order. Thus, the first rib in front corresponds to the fourth rib behind, the fifth to the ninth, the seventh to the eleventh. The seven upper ribs have separate cartilaginous prolongations which connect them with the sternum, and are distinguished as *true* or *sternal* ribs, whereas the lower five are called *false* or *asternal* ribs, because they are not joined directly with the sternum. Of the latter, the eighth, ninth, and tenth ribs have cartilaginous prolongations which unite and turn upward to join the cartilage of the seventh rib so that they are brought indirectly in connection with the sternum. The eleventh and twelfth ribs are without cartilages and terminate in free ends in the muscular walls of the abdomen, and hence are called *floating* ribs. Very rarely the eighth rib presents the anomaly of having an independent cartilaginous prolongation to the sternum (Plate 29), and therefore would then come within the classification of a true rib. Each rib is peculiarly modified in conformation to its position in the series, and from the first to the last they are so remarkably adapted that the slight rotation which can take place only at their vertebral articulations occasions not only a slight elevation of their sternal ends, but an eversion of their lateral surfaces, so that by their united action the thoracic cavity is enlarged in every direction. The vertebral extremities or *heads* of the intermediate ribs, which closely resemble one another in all respects, are covered with articular cartilage, which in all but the first and last three is divided by a slight transverse ridge into two facets for articulation with the bodies of two contiguous vertebræ. The lower facet is the larger, and is received upon the vertebral body which corresponds numerically with the rib.

The *costo-vertebral joints* are each provided with a capsular ligament, including two synovial membranes separated by a *fibro-cartilaginous inter-articular ligament,* which extends from the intervertebral disk to the transverse ridge between the facets on the head of the rib. These joints are reinforced anteriorly by fibres which radiate from the anterior border of the head of each rib to the side of the body of the vertebra above, to the front of the intervertebral disk, and to the front of the body of the vertebra below, forming the *stellate ligament.* The narrowed portion beyond the

head of each rib is called the *neck.* This is smooth in front, but roughened behind for the attachment of the *posterior accessory ligament,* consisting mostly of transverse fibres which connect it with the front of the transverse process of the corresponding vertebra. The neck is generally two and a half centimetres, or about an inch, in length, and ends in a roughened process called the *tuberosity,* which presents on its inner surface a smooth oval facet for articulation with the end of the transverse process of the vertebra. This is also provided with a delicate capsular ligament and encloses a synovial membrane.

The fibres which connect the necks and tubercles to the transverse processes are called, from their relative positions, *anterior, middle,* and *posterior costo-transverse ligaments.* The *anterior* consists of a broad band of fibres extending between the upper border of each rib to the lower border of the transverse process above. It is in relation in front with the intercostal vessels and nerves. The *middle* consists of short fibres which pass from the back part of the neck of each rib to the anterior surface of the adjacent transverse process. The *posterior* consists of a short, strong band which passes obliquely from the top of the transverse process to the neck of the rib just back of the tubercle. Between the last two ribs and the transverse processes of the corresponding vertebræ the middle and posterior costo-transverse ligaments are very loose and allow considerable freedom of motion to these ribs. It should be noted in this connection that the transverse processes of the dorsal vertebræ become more oblique from above downward, and consequently the obliquity of the neck of each rib increases. Beyond the tuberosity each rib is prolonged forward as a narrow, flattened, bony hoop, constituting the *body* or *shaft.* The inner surface is concave and smooth, and the outer surface is rough. The upper border is rounded and thick, and gives attachment to the internal intercostal muscles. The lower border is grooved for the accommodation of the intercostal vessels and nerve, and presents a sharp external edge for the attachment of the external intercostal muscle. The body of each rib from the second to the tenth at a short distance from its neck suddenly bends forward and changes the direction of its curve. At this point of divergence there is upon the external surface an oblique ridge called the *angle,* which upon each successive rib

downward is situated farther outward, and corresponds to the insertion of the slips of the sacro-lumbalis muscle. Furthermore, as each rib approaches its sternal end there is a tendency for the body to twist in its axis, so that the posterior surface behind the angle is inclined downward and inward, while toward the middle of the body the bone is inclined downward and outward. This gives the spiral shape which can best be appreciated when an isolated specimen is placed upon a flat surface, it being then found that both ends cannot be kept down at the same time. In consequence of the obliquity and curvature of the ribs, a pistol-ball upon striking one of them may be deflected in its course, and if it has entered in front may be found in the muscles of the back, or if it has entered from behind may pass out near the sternum. The sternal portions of the ribs are broader, thicker, and more porous than elsewhere, and have cupped depressions in their ends to receive the costal cartilages.

The ribs which have noteworthy individual peculiarities are the two upper and three lower ribs upon each side. The *first* rib is broad, nearly flat, and very curved, but without any twist in its axis. It has a small rounded head, which has only *one* articular facet for articulation with the body of the first dorsal vertebra. The neck is long and slender and ends in a decided tuberosity. In very pronounced specimens the upper surface presents two shallow oblique impressions in front of the middle of the body, which are separated by a slight ridge. The posterior impression is for the subclavian artery, the anterior part of the ridge for the attachment of the scalenus anticus muscle (page 220), and the anterior impression for the subclavian vein. Between the tuberosity and the impression for the subclavian artery there is a rough surface for the scalenus medius muscle. The *second* rib is not so broad as the first, and conforms more to the succeeding ribs below, but it is without any twist and is also flatter. The head is provided with two facets for articulation with the bodies of the first and second dorsal vertebræ. About the middle of the body there is a roughness for the attachment of the scalenus posticus and serratus magnus muscles. On both the first and the second rib the angle is very slightly developed. The *tenth* rib is long and curved, and has only a single facet on its head.

PLATE 35.

Preparation to show the relations of the heart and the great vessels at the root of the neck. The pericardium is opened and held aside.

1. The thyroid notch.
2. The right common carotid artery.
3. The right superior laryngeal nerve.
4. The right superior thyroid artery.
5. The crico-thyroid membrane, with the crico-thyroid artery.
6. The cricoid cartilage.
7. The right supra-scapular artery.
8. The right scalenus anticus muscle.
9. The right subclavian artery.
10. The right brachial plexus of nerves.
11. The right first rib.
12. The right pneumogastric nerve.
13. The innominate artery.
14. The right recurrent laryngeal nerve.
15. The right innominate vein.
16. The right phrenic nerve.
17. The transverse arch of the aorta.
18. The superior vena cava.
19. The upper lobe of the right lung, drawn outward.
20. The pericardium drawn outward to expose the root of the heart.
21. The right auricle of the heart.
22. The middle lobe of the right lung.
23. The right coronary artery of the heart.
24. The pericardium opened and resting upon the diaphragm.
25. The lower lobe of the right lung.
26. The left thyro-hyoid muscle.
27. The left superior thyroid artery.
28. The left superior laryngeal nerve.
29. The left internal jugular vein.
30. The left common carotid artery.
31. The left scalenus anticus muscle.
32. The left brachial plexus of nerves.
33. The left pneumogastric nerve.
34. The left subclavian artery.
35. The left subclavian vein.
36. The left recurrent laryngeal nerve.
37. The left innominate vein.
38. The upper lobe of the left lung, drawn aside.
39. The descending portion of the arch of the aorta.
40. The ascending portion of the aorta.
41. The pulmonary artery.
42. The upper portion of the pericardium, drawn aside to show the root of the heart.
43. The left coronary artery of the heart.
44. The lower lobe of the left lung, drawn aside.
45. The right ventricle of the heart.
46. The apex of the heart.
47. The lower portion of the pericardium, drawn aside to show the apex of the heart.

ected, Photographed and Colored from Nature by George McClellan, M.D

Armstrong & Co. Lith. Boston

The *eleventh* and *twelfth* ribs are less well developed in every respect than the others, and have each a single facet on the head, but are without neck or tubercle and terminate in sharp-pointed extremities. The difference between them is that the eleventh has a slight angle and groove on its under border, while the twelfth has neither. Occasionally there is found a rudimental thirteenth rib on one or both sides in either the cervical or the lumbar region. The sixth, seventh, and eighth ribs are those most frequently fractured, on account of their being usually more exposed than the others.

The cartilaginous prolongations of the ribs, or *costal cartilages,* which bring them in connection with the sternum, resemble in shape the sternal ends of the bony ribs, into which they are fitted without articulation, being merely adjusted and enveloped in a thick perichondrium. In length they increase downward to the seventh, and thence gradually decrease. The first costal cartilage corresponds in breadth to its proper rib, and, like the second, third, and fourth costal cartilages, which are narrower, is continued to the sternum in the line of its rib. The cartilages of the lower true ribs, also narrow, converge upward to be joined to the sternum; the seventh is the largest, and receives the cartilage of the eighth rib at its under surface, as the eighth does that of the ninth and the ninth that of the tenth. The cartilages of the floating ribs are merely tips to the bones. The union of the several cartilages with the sternum offers all the characteristics of a joint, with special differences in some instances.

The *first chondro-sternal joint* is a synchondrosis, the cartilage being continued into a depression on the outer angle of the top of the manubrium sterni, which admits of very little motion. This cartilage is often partially or completely ossified at middle life. The *second chondro-sternal joint* occurs at the junction of the manubrium with the gladiolus of the sternum, and consequently there are double articular surfaces, with an interarticular fibro-cartilage and a synovial membrane. This joint is of topographical value, as it can be located through the superficial structures by its relation to the constant ridge between the manubrium and gladiolus sterni (Plate 28). The succeeding costal cartilages are joined to the margins of the sternum in a manner very closely resembling the attachment of the

head of the first rib to the body of its vertebra. The *seventh chondro-sternal joint* often resembles the first, and has slight motion. Each of these joints is provided with a capsule from the adjoining periosteum, which is strengthened by the *anterior chondro-sternal ligament*, composed of fibres radiating from the ends of the costal cartilages on the front of the sternum, where they interlace with one another above and below and from the opposite side and with the tendinous attachments of the pectoral muscles. The *posterior chondro-sternal ligament* is the corresponding fibrous interlacement on the endothoracic surface of the articulations. The cartilages of the eighth, ninth, and tenth ribs are connected to one another and to the cartilage of the seventh rib by the *interchondral ligaments*. The costal cartilages are very elastic in youth, those of the lower ribs particularly so. In certain diseased conditions these cartilages become ossified and are liable to fracture.

The *sternum*, or breast bone, consists in the adult of three light, flat, spongy bones which are supported by the costal cartilages in the front of the chest, and taken together form a narrow, long, bony mass shaped somewhat like an old Roman sword. The upper portion resembles the handle, and is called the *manubrium* (or *presternum*), the central blade-like portion is the *gladiolus* (or *mesosternum*), and the lower pointed process (usually cartilaginous) is the *ensiform process* (or *metasternum*), which, because of its variability of form and frequently forked termination, is also known as the *xiphoid appendix*. The manubrium is the broadest and thickest part, and presents on each lateral border *three* articular surfaces, the upper of which is the largest, for the articulation with the clavicle (page 324), the middle just below it for the cartilage of the first rib, and the lower *half* facet for the upper border of the cartilage of the second rib. The upper border of the manubrium is on a level with the lower border of the second dorsal vertebra, is smooth, and is noticeable through the skin between the two sterno-clavicular joints as a marked depression, called the *supra-sternal notch*.

The *gladiolus* is ordinarily broadest between the articulations of the cartilages of the fifth ribs. Upon the lateral borders are the articular notches for the rib cartilages, and running across the bone between them

from side to side are imperfectly-marked ridges, indicating the original segmentation in its formation. The *ensiform cartilage* is irregular, notched or bifid, and is often bent forward or to one side owing to some habitual occupation during life, as the pressure exerted by a cobbler's last. There is a *chondro-xiphoid ligament* which extends from the cartilage of the eighth rib on each side to this process.

The chief difference in the length of the sternum in the female (seventeen and a half centimetres, or about seven inches) and in the male (twenty centimetres, or about eight inches) is in the gladiolus, which in the former (Plate 41, Fig. 1) is shorter and broader proportionately than in the latter (Plates 28 and 29). The outer surface of the sternum is slightly convex, the inner concave. Looked at from the side, the anterior surfaces of the different portions will be seen to occupy different planes, so that there is always a slight bend at the junction of the manubrium and gladiolus. The plane of the manubrium inclines forward, that of the gladiolus less so, and the ensiform cartilage is usually vertical, although, as just stated, it is subject to variations. The outer layer of compact tissue which encases the spongy substance of the sternum affords very slight protection, but the periosteal covering is very dense, and thicker than usual in other bones. The joint between the manubrium and gladiolus is rarely ossified, and there is often a decided yielding or tendency to sinking backward of the top of the gladiolus, which has in some instances been erroneously surmised to be the result of fracture. As stated, the *ridge* in this situation is constant, and of the greatest service in counting the ribs, for, as it corresponds to the attachment of the cartilage of the second rib on each side (page 245), it is easy to ascertain any other by counting downward. The median line of the sternum is not continuous with the median line of the abdomen, but inclines rather to the right.

The *intercostal spaces* in relation to the sternum are noticeably wider above and narrower below. The *second intercostal space* is generally the widest (Plate 29), but they all vary with the expansion and contraction of the chest in respiration. They can be increased by bending the body over to the opposite side.

The skeleton of the thorax, considered as a whole, is somewhat flattened

in front and behind, so that its width from side to side exceeds its depth, which is characteristic of the human thorax as compared with that of quadrupeds, and makes the supine position naturally an easy one to man. The *anterior surface* is slightly convex, corresponding to the direction of the sternum and the costal cartilages by which it is formed. The *lateral surfaces* are convex, and formed by the arching bodies of the ribs and the intercostal spaces. The *posterior surface* is also convex from above downward, and is formed by the dorsal vertebræ and the portions of the ribs posterior to their angles. The thorax increases in dimension from the first rib to the eighth, where its transverse diameter is greatest. There is much variability in the form of the thorax at all periods of life, and very commonly there is a want of symmetry in the two sides, the circumference of the right usually being greater than that of the left. In early childhood the thorax is relatively smaller than in the adult, the ribs are flatter and less hooped, and up to the end of the third year breathing is more *abdominal* than thoracic, while after that age, in boys, and in men too, it is effected by the action of the muscles attached to the lower seven ribs as well as the diaphragm. In adult females the upper portion of the thorax is less compressed from before backward, and the upper ribs are naturally brought more into play, even when not influenced by artificial pressure, so that in them breathing is *thoracic.* A horizontal section made through the middle of the thorax (Plate 41, Fig. 2) presents a cordiform or heart-shaped outline, owing to the projection of the bodies of the dorsal portion of the vertebral column into the back of the thoracic cavity. Such a section will also show that the ribs are cut *obliquely.* In the male a section made on a level with the lower borders of the third ribs anteriorly and through the body of the eighth dorsal vertebra posteriorly will generally cut the eighth, seventh, sixth, fifth, and fourth ribs (Plate 41, Fig. 2).

The *dorsal vertebræ,* or, more properly, *thoracic vertebræ,* are peculiarly adapted with facets and demi-facets for the articulation of the ribs. The *first* corresponds in general conformation to the vertebra prominens of the neck, and the *last* to the first vertebra of the lumbar region. Their bodies are thicker behind than in front, as are also the dorsal intervertebral disks, so that when they are articulated they present a natural curvature with the

convexity backward. The dorsal spines are very oblique, and it should be remembered that their tips do not correspond to the bodies. That of the first is opposite the disk between the first and second bodies; that of the second is opposite the body of the third; that of the fourth is on a level with the disk between the fifth and sixth; those of the fifth, sixth, seventh, and eighth are opposite the seventh, eighth, ninth, and tenth. That of the ninth corresponds to the body of the tenth, the tenth to the eleventh, and the eleventh is opposite the disk between the eleventh and twelfth. The further description of the dorsal vertebræ will be found under the anatomy of the back, in Vol. II.

The terms superior and inferior apertures of the thorax are misleading, such openings existing only in the skeleton. The superior, corresponding to the *summit* of the thorax, gives passage to the structures at the root of the neck and to the dense fibro-cellular tissue which is prolonged over them from the deep cervical fascia into the thoracic cavity. The inferior opening, or *base*, is closed in the recent state by the diaphragm, which forms a muscular partition between the chest and the abdomen. Although the diaphragm is arched upward to a considerable extent and its muscular portions fall and rise continually in unison with the efforts at respiration, thereby alternately increasing and diminishing the capacity of the thorax, the actual space occupied by the lungs and heart is very limited compared to that indicated by the outward appearance of the bony cage. The diaphragm (page 320) is on a level with the junction of the fifth costal cartilage and rib on the right ride, and of the sixth on the left (Plate 27), corresponding to the height to which the liver reaches. It is attached in front to the ensiform cartilage, but it curves downward to become attached to the last rib on both sides.

The *skin* over the anterior surface of the thorax is delicate and closely connected with the superficial fascia. It is tense and very slightly movable over the sternum, but at the sides, in consequence of the traction exerted by the underlying muscles, the pectoralis major and minor and the latissimus dorsi, forming the folds of the axilla, it is freely movable. The skin over the sternum in dark-hued males is usually the seat of the growth of curly black hairs associated with large sebaceous glands. The superficial

fascia is generally loose, and does not contain much fat except in relation to the mammæ, where the fascia subdivides into two layers which surround these glands and send numerous septa between their various lobes. The *ligamenta suspensoria* are fibrous processes which project from the anterior layer to the skin around the nipples.

The mammary glands in the female (Plate 44, Fig. 1) extend from the third to the sixth rib on each side between the axillæ and the sternum. They vary in size and shape according to their functional development and the general physical condition of the individual. When fully formed, with the enveloping skin, fascia, and fat, they appear as globular prominences, the *breasts*, from which protrude conical, brownish-pink-colored eminences, the *nipples*, which are surrounded at their bases by a zone of colored skin, the *areola*. The nipple is usually situated opposite the fourth intercostal space, and twelve centimetres, or about four and a half inches, from the middle line; but its position is variable and cannot be relied upon as a reference for definite measurement (Plate 27). The skin of the areola is extremely thin, and is covered with a number of little whitish tubercles which contain the orifices of sebaceous glands. The skin of the nipple is provided with sensitive papillæ, and consists of retiform tissue interspersed with unstriped muscular fibres. It is highly vascular. The milk-ducts open upon the summit of the nipple by from fifteen to twenty orifices. The *mammary gland* is a racemose glandular structure, consisting of from fifteen to twenty lobes, which are supported by the septa inflected from the anterior layer of the fascial investment. The lobes are quite independent of one another, so that in mammary abscess it is often necessary to make several openings, and they should be made in a straight direction radiating from the nipple, in order to avoid as far as possible injuring the milk-ducts.

The *arteries* which enter the margins of the gland are small and numerous, and they do not accompany the ducts. Those for the upper lobes are derived from the thoracico-acromial artery, those for the outer lobes from the long thoracic and external mammary arteries, and those for the inner lobes from the anterior intercostal arteries (Plate 44, Fig. 1). The deep *veins* accompany the arteries; the superficial veins form an

anastomosing circle around the base of the nipple and end in the superior thoracic veins.

The *lymphatic vessels* are numerous, and chiefly converge toward the axillary glands, following the outer border of the great pectoral muscle (Plate 44, Fig. 2), while others terminate in the anterior mediastinal glands in relation to the internal mammary vessels (Plate 41, Fig. 1), penetrating the thoracic walls through the upper three intercostal spaces. The distinction between the sub-sternal and axillary glands with reference to their possible involvement in cancer should be clearly understood. The former receive the lymphatic vessels from the inner portion of the breast, so that in cases where they have become implicated they are anatomical obstacles to the effectual removal of a scirrhous breast, notwithstanding the most thorough enucleation of the axillary glands with the tumor. The superficial lymphatics from the vicinity of the nipple pass to a gland below the outer border of the clavicle.

The *nerves* are chiefly derived from the anterior and lateral cutaneous branches of the intercostal nerves. The superficial fascia along the border of the sternum is pierced by the anterior cutaneous branches of the intercostal nerves, which emerge with the anterior intercostal branches of the internal mammary artery, the second, third, fourth, and fifth being distributed to the mammary gland. The connections of the intercostal nerves explain the diffusion of pain complained of in many affections of the breast. In the female there is always a loose layer of connective tissue underneath the gland, and often a bursa, which allows it to glide freely over the pectoral muscle, to which it is in no way attached in the healthy state. In the male the gland is rudimental, and, as the substratum of connective tissue is less loose, it follows to a greater extent the movements of the pectoralis major muscle. Occasionally the male mammæ are developed, and in rare instances have been known to secrete milk; and there are numerous recorded cases of supernumerary mammæ in the female, variously situated in the back, axilla, groin, and thigh. In the female the various modifications which the breasts assume after puberty are coincident with the other phenomena attendant upon pregnancy.

In the *operation for removal of the breast* the arm of the affected side

PLATE 36.

Dissection of the pneumogastric nerve on the left side, and its relations to the phrenic and sympathetic nerves. (From a female, aged thirty-seven years.)

1. The parotid gland.
2. The digastric muscle.
3. The styloid process.
4. The stylo-glossus muscle.
5. The lingual (or gustatory) nerve.
6. The hypoglossal nerve.
7. The glosso-pharyngeal nerve.
8. The lingual artery.
9. The digastric muscle attached to the hyoid bone by the loop of deep fascia.
10. The great cornu of the hyoid bone.
11. The attachment of the omo-hyoid muscle to the hyoid bone.
12. Section through the symphysis of the lower jawbone.
13. The superior laryngeal nerve.
14. The crico-thyroid muscle.
15. The superior thyroid artery.
16. The top of the thyroid cartilage.
17. The descendens hypoglossi nerve.
18. The right sterno-thyroid and hyoid muscles.
19. The thyroid body.
20. The internal jugular vein.
21. The pneumogastric nerve.
22. The lower cervical ganglion of the sympathetic nerve.
23. The common carotid artery.
24. The recurrent laryngeal nerve.
25. The innominate artery.
26. The sternal end of the right clavicle.
27. The left innominate vein.
28. The left first rib.
29. The anterior margin of the right lung.
30. The ascending portion of the arch of the aorta.
31. The right second rib.
32. The right auricle.
33. The right third rib.
34. The left phrenic nerve.
35. The apex of the left ventricle of the heart.
36. The branches of the posterior coronary artery.
37. The right fifth rib.
38. The right sixth rib.
39. The gastric branches of the left pneumogastric nerve.
40. The diaphragm over the liver.
41. The right seventh rib.
42. The sawn end of the ramus of the lower jawbone.
43. The occipital artery.
44. The spinal accessory nerve.
45. The trapezius muscle.
46. The internal jugular vein.
47. The second cervical spinal nerve.
48. The third cervical spinal nerve.
49. The upper—long—cervical ganglion of the sympathetic nerve.
50. The external carotid artery.
51. The internal carotid artery.
52. The descendens hypoglossi nerve.
53. The omo-hyoid muscle.
54. The scalenus anticus muscle.
55. The sympathetic nerve.
56. The left phrenic nerve.
57. The cords of the brachial plexus of nerves.
58. The subclavian artery.
59. The subclavian vein.
60. The insertion of the scalenus anticus muscle at the inner border and upper surface (tubercle?) of the first rib.
61. The pneumogastric nerve.
62. The œsophagus (distended).
63. The first intercostal artery coming from the subclavian artery.
64. The internal mammary artery.
65. The left innominate vein.
66. The second intercostal artery and nerve.
67. The origin of the subclavian artery.
68. The left third rib.
69. The sympathetic nerve.
70. The left third intercostal artery and nerve.
71. The transverse portion of the arch of the aorta.
72. The left fourth rib.
73. The left fourth intercostal artery and nerve.
74. The left fifth rib.
75. The pulmonary artery.
76. The left fifth intercostal artery and nerve.
77. The roots of the pulmonary vessels and bronchi.
78. The sixth intercostal artery and nerve.
79. The œsophageal branches of the pneumogastric nerve.
80. The great splanchnic nerve.
81. The left auricle of the heart.
82. The seventh intercostal artery and nerve.
83. The lesser splanchnic nerve.
84. The azygos minor vein.
85. The pneumogastric nerve.
86. The left eighth rib.
87. The diaphragm arching over the spleen.
88. The phrenic nerve.
89. The gastric branches of the pneumogastric nerve passing through the diaphragm to the stomach.
90. The terminal branches of the pneumogastric nerve.
91. The spleen.
92. The stomach.

should be drawn upward and backward, so as to put the great pectoral muscle on the stretch, and a bevelled incision should be made, first on one side and then on the other, around the base of the gland, in a direction toward the axilla. The *entire* gland, including the nipple, should always be extirpated, to avoid as far as possible a recurrence of the morbid state, and if the axillary glands are involved, as they generally are in cancer, the incision can be extended so as to expose them. They will be found surrounding the deep vessels (Plate 45), and often adherent to the axillary vein and its tributaries, so that their removal is very difficult and hazardous, whereas the excision of the gland alone is comparatively a simple and easy task. Upon complete removal of the gland, its base will be found to conform with the slight bulge of the subjacent pectoralis major muscle, which with its sheath of deep fascia will be seen usually untouched at the bottom of the wound.

The deep fascia of the anterior surface of the thorax is exposed after removal of the double layer of the superficial fascia and the contained mammary gland. It serves as a thin aponeurotic sheath for the great pectoral muscle, into which it sends prolongations between its component fasciculi. This fascia is attached to the front of the sternum and to the clavicle. It is very delicate over the upper part of the pectoralis major; but, as it is reflected from the outer border of that muscle across the axillary space to the latissimus dorsi muscle, it becomes considerably thicker. It is continued under the latter muscle to the spinous processes of the dorsal vertebræ. Below the deep thoracic fascia is quite strong and blends with the sheaths of the recti muscles.

The *pectoralis major muscle* (Plate 16, and Plate 44, Fig. 1) is the large, triangular, fleshy mass situated at the side of the chest, consisting of two special portions, the fibres of which converge toward the shoulder. The *clavicular portion* arises chiefly by fleshy fibres from the front of the inner half of the clavicle and the capsule of the sterno-clavicular joint, and extends obliquely outward, when the arm is at the side of the body, to the insertion of the deltoid muscle, with which it blends on the surface of the shaft of the humerus, and also gives off an expansion to the brachial fascia. In relation to the deltoid muscle above, the clavicular

portion is separated only by a *furrow* which lodges the cephalic vein and the humero-thoracic artery. When this furrow is marked, the coracoid process can be felt through it and may be a useful landmark (page 330). The *sternal portion* is peculiar in the manner both of origin and insertion of its fibres, which are arranged in two layers which are often quite distinct from each other, being separated by a cellular interval. The superficial layer arises by tendinous fibres from the front of the sternum interlacing with those from the opposite muscle, and usually by a slip from the sheath of the rectus abdominis muscle. The deeper layer arises by fleshy fibres from the cartilages of the five or six upper true ribs, the slip from the first costal cartilage being sometimes absent. The fibres of these two layers are directed in a radiating manner toward their insertion, being disposed in such a manner that the fibres of the deeper layer pass obliquely upward under the fibres of the superficial layer, so that their relative positions are reversed, the lower becoming the upper, as they terminate in a flat tendon at the *outer margin* of the bicipital groove under the insertion of the clavicular portion. The attachment of the sternal portion gives off a delicate expansion which covers the bicipital groove and is connected with the capsular ligament of the shoulder-joint. The twist in the sternal portion produces the anterior rounded border of the axilla, and covers the axillary vessels and nerves at the upper part of that space.

The pectoralis major muscle is remarkable for its tendency to separate into radial lamellæ, commonly offering accessory slips which pass to the humerus or the brachial fascia. Its function is chiefly to draw the arm forward and rotate it inward upon the chest. When the arm is raised it can draw it downward, or, if the fixed point is above, the muscle can assist in raising the trunk, and also serve as an auxiliary muscle of inspiration. The arteries to this muscle come from the long and short thoracic branches of the axillary artery. The nerves are derived from the anterior thoracic branches of the subjacent brachial plexus. The *cleft* between the clavicular and sternal portions of the pectoralis major muscle, when the arm is extended outward, is often clearly indicated by a depression in the skin, and, as it corresponds to the course of the commencement of the axillary

artery, that vessel may be sought for here and a ligature applied with considerable ease (page 343).

The pectoralis major muscle must be removed in order to expose the pectoralis minor and subclavius muscles. The former will be found separated from the sternal portion of the pectoralis major by a quantity of loose cellular tissue, and the latter beneath the clavicular portion, enclosed in the strong costo-coracoid membrane. The *pectoralis minor muscle* (Plate 44, Fig. 2) is a triangular fleshy mass composed of fibres which arise by flattened tendinous slips from the sternal ends of the third, fourth, and fifth ribs, and from the aponeurotic expansion over the subjacent intercostal muscles. Besides these there are often accessory slips of origin, either above or below. It ascends to be inserted by a narrow, flat tendon into the upper and inner edge of the coracoid process of the scapula, and gives a fibrous extension to the coracoid attachments of the coraco-brachialis and biceps muscles. The insertion of the pectoralis minor passes across the middle of the axillary vessels and nerves (page 339). Between the pectoralis minor and major muscles there are branches of the thoracico-acromial artery and the anterior internal thoracic nerve. The long thoracic artery runs along the axillary border of the pectoralis minor. The function of this muscle is to depress the shoulder, by drawing the scapula forward and downward.

The *costo-coracoid membrane* consists of several leaflets of fascia of varying density, extending from the cartilage of the first rib to the coracoid process. Above it is attached to the outer and inner edges of the *subclavian impression* on the under surface of the clavicle, and thus completely encloses the subclavius muscle. The outward and more superficial expansion is thin, and splits so as to pass over and under the coracoid attachment of the pectoralis minor muscle, to be continued with the axillary fascia, forming the *anterior part* of the sheath of the axillary vessels. This leaflet is pierced by the cephalic vein, the thoracico-acromial artery and vein, the anterior thoracic nerves, and the superior thoracic artery. The deeper portion of this membrane is called the *costo-coracoid ligament*, because of its strong fibrous character. It arches over the axillary vessels and nerves as they pass over the first rib.

The *subclavius muscle* is a round mass of fibres which arises by a strong tendon from the junction of the first rib and its cartilage, and is inserted into the subclavian impression of the clavicle as far as the coraco-clavicular ligament. It receives filaments from the lower cervical nerves, and its function is to fix and depress the clavicle.

When the above muscles are completely removed from the anterior surface of the thorax there is a strong glistening aponeurotic layer of fascia spread over the intercostal spaces, which serves to bind down the fibres of the intercostal muscles and to afford additional protection to the spaces. The intercostal muscles consist of two separate layers, external and internal, the short fleshy fibres of which cross one another. There are eleven pairs of each set of intercostal muscles, and they are arranged peculiarly as they approach the vertebral and sternal ends of the ribs.

The *external intercostal muscles* commence at the tubercles of the ribs, pass obliquely from the outer border of the rib above to the top of the rib below, throughout the series, and extend as far forward as the costal cartilages, where the muscular fibres disappear and are replaced by strong, oblique, tendinous fibres, which constitute a membranous expansion, to the border of the sternum. The *internal intercostal muscles* commence at the sternum and pass obliquely in the opposite direction to the external muscles from the inner edge of the groove above and from the costal cartilage to the upper border of the rib below, as far backward as the angles of the ribs, where they are reinforced by additional fibres, the *subcostal muscles*, which extend upward and downward, passing over one or two ribs between their attachments. The direction of the fibres of the external intercostals corresponds to the external oblique muscle of the abdomen, and that of the internal intercostals is similar to the internal oblique. The internal intercostals are thicker and their muscular fibres more pronounced anteriorly (Plate 40) than they are posteriorly. The intercostal muscles are exercised chiefly in the movements of the ribs in ordinary breathing. When the first and second ribs are fixed by the scalene muscles the action of the external intercostals raises the anterior part of the ribs and everts their lower borders, thus enlarging the thoracic cavity, as in inspiration. The special action of the internal intercostals is not definitely

understood, but they probably depress the ribs, as in expiration. In the spaces between the costal cartilages the two sets of fibres, it is supposed, assist each other in inspiration. The internal surface of the intercostal spaces is covered with a thin adherent fascial expansion similar to that upon the outer side of the chest wall. It is closely connected with the outer layer of the pleura.

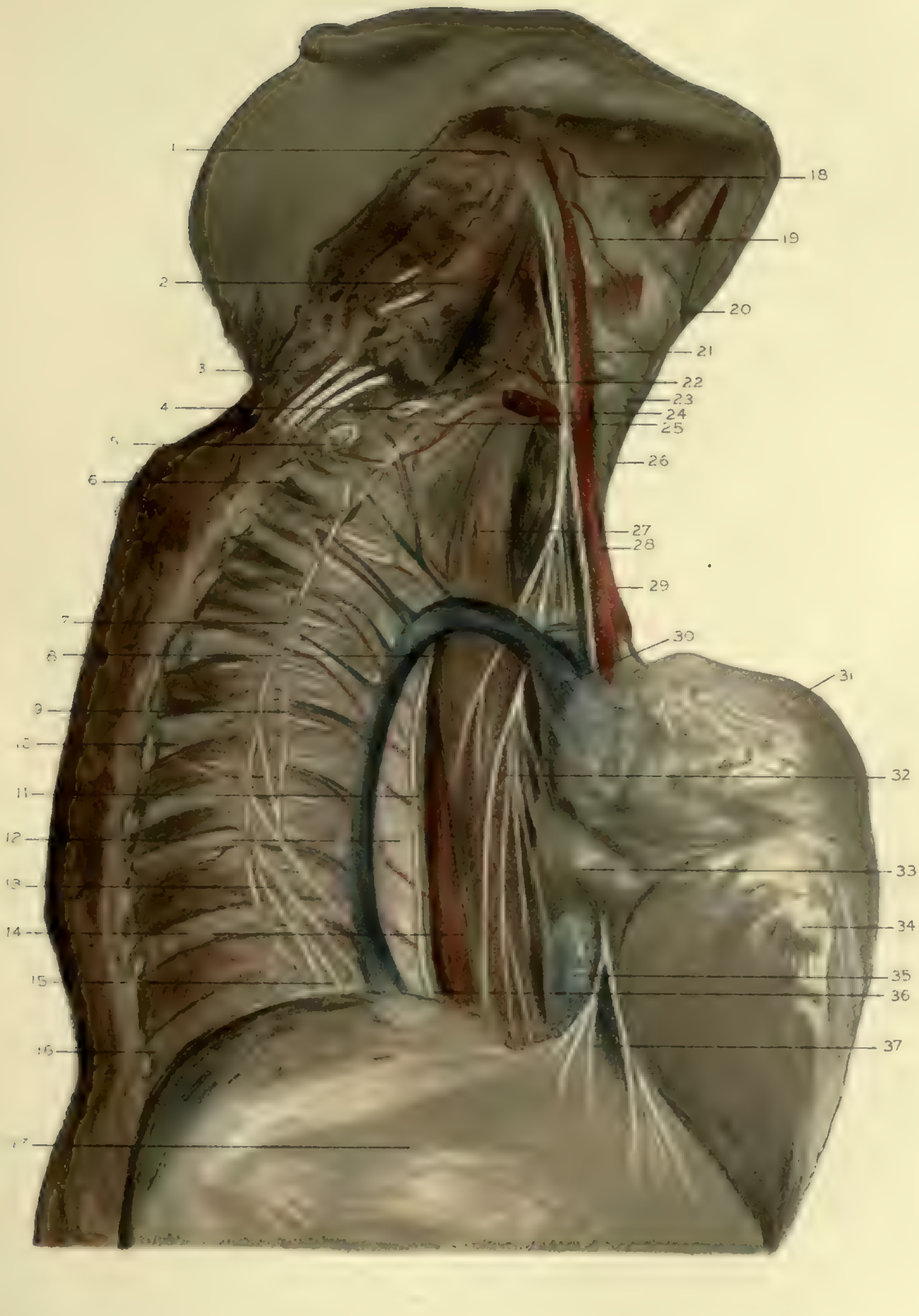
Within the thorax, on the under surface of the sternum and cartilages of the lower true ribs, there is a thin, flat muscle, of variable development, called the *triangularis sterni.* It arises from the ensiform cartilage and the sides of the lower part of the gladiolus and the adjacent cartilages, and ascends obliquely outward, to be inserted, by fleshy slips, into the cartilages of the lower true ribs, generally from the sixth to the third. The fibres of the lowest slip pass transversely outward, and are in reality continuous with the anterior portion of the transversalis abdominis muscle. The action of the triangularis sterni muscle is to depress the costal cartilages in expiration. Its nerves are derived from the intercostal nerves, and its arteries are branches of the internal mammary on both sides, which are situated between it and the costal cartilages.

The *internal mammary artery* on either side is given off from the first portion of the subclavian artery, opposite the origin of the thyroid axis at the inner border of the scalenus anticus muscle, and descends into the thorax behind the clavicle and the first rib, in close relation to the phrenic nerve, which passes over it from without inward to descend behind the artery (Plates 39 and 40) between the pleura and the pericardium. The internal mammary artery with a vein on each side of it runs parallel with the border of the sternum, and twelve millimetres, or about half an inch, from it (Plate 41, Figs. 1 and 2), on the surface of the pleura, until it reaches the fifth or sixth intercartilaginous space, where it passes between the cartilages and the triangularis sterni muscle. This artery can be easily ligated within the second intercostal space through an incision directly over its course. In relation to the seventh costal cartilage it divides into its terminal branches, the *musculo-phrenic,* which supplies twigs to the diaphragm and the lower intercostal muscles, and the *superior epigastric,* which enters the abdominal wall between the sheath of the rectus

PLATE 37.

The posterior mediastinum, exposed on the right side by removing the ribs near their angles and drawing forward the heart and lungs, to demonstrate the entrance of the vena azygos major into the superior vena cava, and the distribution of the right pneumogastric and phrenic nerves.

1. The right occipital artery.
2. Section of the sterno-mastoid muscle.
3. The cut brachial plexus of nerves.
4. Section of the first rib.
5. Section of the second rib.
6. Section of the third rib.
7. The chain of ganglia of the sympathetic nerve.
8. The thoracic duct, crossing behind the œsophagus and aorta to the left side.
9. The intercostal vessels and nerve in relation to the seventh rib.
10. The seventh rib.
11. The thoracic duct.
12. The vertebral column, covered with the thoracic fascia.
13. The greater splanchnic nerve.
14. The descending thoracic aorta.
15. The lesser splanchnic nerve.
16. Section of the eleventh rib.
17. The hepatic arch of the diaphragm.
18. The lingual artery,
19. The descending thyroid artery, and superior laryngeal nerve.
20. The notch in the thyroid cartilage.
21. The common carotid artery.
22. The thyroid axis.
23. The cricoid cartilage.
24. The right subclavian artery.
25. The first intercostal artery.
26. The trachea.
27. The œsophagus.
28. The innominate artery.
29. The right phrenic nerve.
30. The vena azygos major vein, entering into the superior vena cava.
31. The heart, within the pericardium, drawn forward.
32. The œsophageal plexus of nerves, from the pneumogastric nerve.
33. The right auricle of the heart, within the pericardium.
34. The right lung, drawn outward.
35. The inferior vena cava, emptying into the right auricle of the heart.
36. The thoracic duct, coming through the aortic opening in the diaphragm.
37. The branches of the right phrenic nerve on the diaphragm.



Drawn and colored from nature by George McClellan M.D.

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abdominis muscle and the extra-peritoneal fascia and anastomoses with the deep epigastric. In its course it distributes a branch which accompanies the phrenic nerve, the *arteria comes nervi phrenici*, branches to the structures within the anterior mediastinum, branches which pass to the five or six upper intercostal spaces and inosculate with the aortic intercostal arteries, and perforating arteries which pass through the intercostal spaces and supply the pectoralis major muscle, the mammary gland (page 250), and the skin over the chest. At the first rib there is a lateral infracostal branch from the internal mammary, which in intra-thoracic growths sometimes becomes greatly enlarged. The two *internal mammary veins* are usually of unequal size, and are provided with a number of valves. Behind the first intercostal muscle the veins unite and empty on the left side into the innominate vein, and on the right, generally, into the superior vena cava. In close proximity to the internal mammary vessels there are from six to eight *lymphatic glands*, which receive the lymphatic vessels from the upper part of the rectus abdominis muscle, the diaphragm, the intercostal spaces, and the inner portion of the mammary gland (page 251). They empty into the right lymphatic duct and left thoracic duct respectively.

If the sternum and costal cartilages are carefully removed, the anterior wall of the thorax will be opened so as to display the prolongation of the deep cervical fascia downward and the anterior surfaces of the right and left pleural sacs. In the middle line there is a tubular expansion of fascia extending between the pleuræ all the way from the neck to the ensiform cartilage of the sternum, and on each side the fascia becomes thickened and is attached to the pericardium, forming the *sterno-pericardial ligaments.* The sub-sternal tubular sheath can generally be demonstrated by inflation with a blow-pipe, and may allow pus to travel from the root of the neck and point below the ensiform cartilage in the upper part of the abdominal wall. Upon slitting up this layer of fascia the subdivision of the interpleural space, called the *anterior mediastinum*, is exposed (Plate 26, Fig. 1). This is a shallow space included between the anterior portions of the pleuræ, the pericardium, and the sub-sternal fascia just described, especially that portion of it which corresponds to the gladiolus. Its direction is usually not vertical, as it inclines to the left side because of the position of the heart,

over the root of which, opposite the origin of the great vessels, it is also narrowest, owing to the approximation of the pleuræ. As the left pleura recedes from the middle line, this space is wider below than it is above. Within the anterior mediastinum there are the sub-sternal lymphatic glands, embedded in a variable amount of fatty tissue, and on the left side the internal mammary vessels for a part of their course (Plate 41). The space does not properly enclose the attachments of the triangularis sterni, sterno-hyoid, and sterno-thyroid muscles, as they are covered by reflections of the endothoracic fascia continuous with the deep cervical fascia. The so-called *superior* mediastinum is that portion of the inter-pleural space which extends from the manubrium in front to the upper dorsal vertebræ behind and above the pericardium. It contains, besides the great vessels and contiguous portions of the trachea and œsophagus, the *thymus gland* in the infant or its remains in the adult. It is not truly separated from the anterior mediastinum except when the expansion of the lungs in full inspiration brings their pleural envelopes into contact.

The thymus gland is a soft, grayish-red-colored, lobulated body, of variable size and shape, situated behind the manubrium sterni and overlapping the great vessels of the heart covered with the pericardium (Plate 26, Fig. 3, No. 6). At birth it is five centimetres, or about two inches, in length, wider below than above, and it continues to grow until the end of the second year, often ascending into the root of the neck, and sometimes reaching the lower border of the thyroid body. From the second year to the sixth it does not undergo much change, but after the latter age it gradually atrophies, and at puberty there is very little trace of its original glandular structure left, a fatty mass taking its place and rarely projecting above the sternum. It bears much resemblance to the racemose glands, but its function is unknown. It seems to be the great functional lymphatic gland of early life, each lobe consisting of lobules composed of clusters of lymph-follicles surrounded with vascular connective tissue and numerous lymph-cells. The branches from the internal mammary arteries furnish it with most of its blood.

The pleuræ (Plate 26, Fig. 1, Nos. 6 and 16) are the serous mem-

branes surrounding the lungs, and are so arranged as to form two distinct completely closed sacs, each having a *parietal layer*, or *pleura costalis*, which is in contact with the thoracic wall, and a *visceral layer*, or *pleura pulmonis*, which is reflected over the contained lung. The enclosed space between the two layers of each pleura is called the *cavity of the pleura*, the surfaces of which are smooth and moist, but it is not ordinarily of appreciable dimensions. It is now regarded as a large lymph-space, like that of the peritoneum, and communicates by stomata with the surrounding subpleural lymphatic vessels. During life, when healthy, the two layers glide freely upon each other, and thereby facilitate the movements of the lungs. The costal pleura is the thickest, and is connected especially to the inner surfaces of the ribs by a well-marked connective tissue, which allows of its being easily detached. The pulmonary pleura is very delicate and transparent, and is also attached to the lung tissue by elastic connective tissue, which serves as a nidus for a plexus of capillaries from the bronchial arteries, and a plexus of lymphatic vessels which communicate with the lymph-spaces in the areolar tissue of the lobules of the lung. Inflammation of the pleura may produce a thickening and roughening of its lateral surfaces, so that in the expansion of the lung a *friction* sound is produced. This is peculiarly modified if the inflammation results in a distention of the pleural sac by serum (hydrothorax), or by pus (empyema), or by air (pneumothorax). When the cavity of the pleura requires tapping (paracentesis thoracis) to evacuate it of an accumulation of fluid, the sixth or seventh intercostal space, midway between the sternum and the spine, is generally selected, and the trocar should always be introduced at the middle of the space, during inspiration, to avoid the intercostal vessels and nerves. On the right side the fifth intercostal space should be selected, in order to avoid the diaphragm (Plate 27). The right and left pleural cavities are distinct, and their respective membranes are reflected posteriorly from the roots of each lung, in connection with a fold of the prevertebral fascia, to the diaphragm below, having a free curved edge between the diaphragm and the lung. This is called the *ligamentum pulmonale*. As the apices of the lungs extend upward into the root of the neck behind the attachments of the scalenæ antici muscles on the first ribs, their pleuræ naturally are

similarly expanded. On the right side the pleura usually reaches a little higher than on the left. In this position it bears an important relation to the subclavian artery in its first portion. At the root of the neck the endothoracic fascia is expanded somewhat in the shape of a dome, to which the deep cervical fascia is usually attached. Sometimes there is a prolongation of this fascia, which brings the dome into relation with the transverse process of the seventh or sixth cervical vertebra, and a few muscular fibres have been found in it, probably segmented from the scalenus posticus muscle. The parietal layer of the pleura over the apex of each lung is intimately connected with this dome-like expansion of the fascia. The presence of this *extra*-pleural fascia at the root of the neck, with its possible modifications consequent upon any inflammatory infiltration, is worthy of the consideration of the physician, who may be confused by the adventitious sounds produced by it upon auscultation, in the same manner as the surgeon finds it often difficult to distinguish between true and false crepitus in injuries about the joints. The extent and limitation of the reflections of the pleuræ upon the inner wall of the thorax are very difficult to understand without actual demonstration. Below they practically follow the attachments of the diaphragm, which, except about its margin and at its central tendon, is covered by the pleuræ. In front the right pleura holds a position more nearly the middle line, being opposite the junction of the seventh rib and its cartilage, while the left is placed at a variable distance away from it and a little lower, in consequence of the interposition of the heart. Posteriorly both pleuræ descend as far as the head of the last rib, and laterally the right pleura is in relation to the lower border of the *ninth* rib, and the left pleura to the lower border of the *tenth* rib. In consequence of this disposition of the pleuræ over the diaphragm it often happens that a pistol-ball which has penetrated the thoracic wall will roll down over the diaphragm to the lowest part of the back of the pleural cavity.

The pulmonary layers of the pleura upon each side are not coextensive with the costal layers, except during forced inspiration. Therefore there are portions of the folds of the pleuræ where their surfaces ordinarily are in contact. These are called the *pleural sinuses*, and they

are found along the costal origins of the diaphragm, between the pericardium and the sternum, and between the pericardium and the diaphragm (Plate 26, Fig. 1, No. 8). Upon the anterior margins of the last two sinuses there are folds which blend with the tissue of the pericardium, and through which the phrenic nerves on their way to the diaphragm can be seen in front of the roots of the lungs. If a transverse section of the thorax is made, it will be noticed that the pleuræ do not come into contact, and that there is a distinct space between them extending from before backward (Plate 41, Fig. 2). This is called the *interpleural space*, and is subdivided into the anterior, middle, and posterior mediastina. Of these the middle is the largest compartment, and contains the heart within the pericardium, the vessels which pass to and from the base of the heart, the phrenic nerves, and the bifurcation of the trachea and the bronchial lymphatic glands. The anterior mediastinum is in front of the pericardium, and, as it is first exposed upon opening the thorax anteriorly, it has already been described (page 259), as being in the natural order of approaching the study of this region. The *posterior mediastinum* is behind the pericardium, between it and the dorsal vertebræ, from the fourth to the twelfth, and contains the descending thoracic aorta, the œsophagus, the pneumogastric nerves, the venæ azygos major and minor, the thoracic duct, and lymphatic glands (Plate 38).

The lungs are two large spongy organs within the pleuræ, occupying during life the whole of the cavity of the thorax on each side of the mediastinum, and separated from each other by the heart enclosed in the pericardium. They vary even in health from a pale-pinkish color to a mottled gray, depending upon their vascularity and inflation. With age they generally become darker and spots are visible upon their surface, probably due to the deposition of particles of carbonaceous matter which have been inhaled. After death they usually appear of a dark-purple hue, especially at the back, in consequence of venous stagnation. When the lungs are fully distended, as in forced inspiration (Plate 30), they will be seen to conform to the shape and limitation of their respective pleura. Each lung has a rounded *apex*, which extends into the root of the neck (Plate 27) two and a half centimetres, or about an inch, within the pleural

domes (page 262), and a concave *base,* which conforms to the arch of the diaphragm upon which it rests. They fit into the pleural sinuses when fully expanded, and reach downward posteriorly as far as the eleventh rib on each side,—the right lung in the axillary line being in relation to the ninth rib, and the left lung to the tenth rib.

The right lung is thicker and shorter than the left, the concavity of its base being also higher, as it corresponds to the arch of the diaphragm over the liver. It is often notched on its mediastinal surface, presenting depressions foı the superior and inferior venæ cavæ. The left lung is excavated on its mediastinal surface for the reception of the heart, and its apex has an impression for the left subclavian artery. The apex of the left lung does not mount quite so high above the clavicle as does that of the right. The anterior edges of both lungs present characteristic differences. That of the right lung is nearly straight or vertical, and that of the left is oval or oblique. The extent to which they approach each other depends upon the degree of their expansion. In forced inspiration, when the lungs are absolutely healthy, the anterior edges of the lungs *meet* over the root of the heart and the origin of the great vessels within the pericardium (Plate 30). The surfaces of the pleuræ are thus brought into contact to the extent of several inches, between the lower border of the manubrium sterni and the junction of the cartilages of the fourth ribs with the sternum. At such times the anterior edge of the right lung is absolutely vertical and parallel with the median line of the chest, and the area of the heart which is uncovered by the left lung is limited to the lower third of the right ventricle. In ordinary tranquil breathing the anterior edges of the lungs do not come together (Plates 31 and 32). In a state of collapse both lungs shrink back into their recesses within the thoracic cavity (Plate 33).

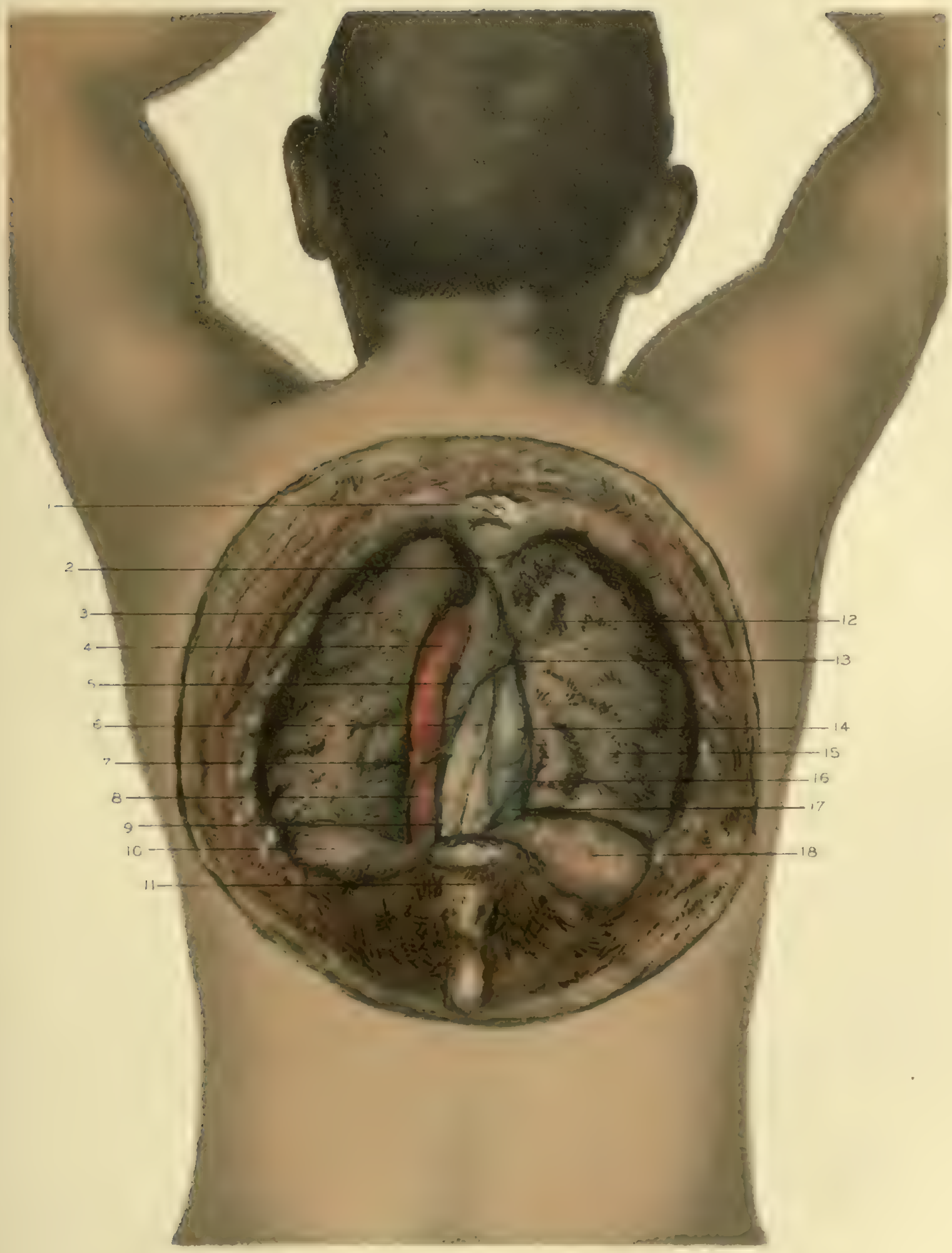
From careful observations made upon both the living and the dead body at different ages, it would seem to the author that only when healthy do the lungs meet in front over the root of the heart upon a prolonged and full inspiration. There is generally some interspace between them in the anterior mediastinum. The right lung comes forward more readily than does the left, even in moderate inspiration, so that the anterior edge

of the right lung approaches more nearly the middle line. The lower portion of the right lung also expands more readily below in relation to the diaphragm than does the lower portion of the left lung, whereas the converse appears to be true with regard to their apices. Not only does the left lung not come forward so readily, but its lower portion does so only upon prolonged inspiration, and thereby reaches the anterior limit of its pleural sac. When both lungs are normal and fully inflated in the well-developed adult male, in the erect position, the lower front edge of the right lung corresponds approximately to the oblique line of the interspace between the cartilages of the sixth and seventh ribs (Plate 27), while the lower front edge of the left lung is in relation to the lower border of the seventh rib, and extends but a little way beyond the sternal end of that rib (Plate 30). These limitations will be lessened by the breadth of a rib if the individual be placed in the recumbent position, and in the female or poorly-nourished youth they may be lessened still more, so that the anterior lower edges of the right and left lungs may reach respectively the lower borders of the fifth and sixth ribs, corresponding to the height which the arches of the diaphragm normally reach and hold relatively (page 322) to each other. It should be therefore understood that in respiration the upper portions and posterior surfaces of the lungs are at all times in close contiguity with their pleural sacs, and that the anterior medial and lower edges retire and advance according to the effort of expiration or inspiration and the healthy condition of the pleuræ which allows their natural freedom of motion. It is very doubtful if the anterior lower edges of the lungs ever do completely fill their proper portions of the pleural cavities, and an adhesion existing anywhere between the lung and its sac will influence the degree of motion of the lung. In forced expiration the lower edges of the lungs posteriorly do not ascend higher than the lower borders of the *seventh* ribs. A transverse section made across the root of the neck from the first dorsal vertebra to the top of the sternum (Plate 14, Fig. 1) will show that the apex of the right lung is larger than that of the left, and that they are both in this locality of oval form. A transverse section across the thorax from the eighth dorsal vertebra to the lower borders of the third ribs (Plate 41, Fig. 2)

PLATE 38.

The posterior mediastinum and its contents, as seen on removal of the dorsal vertebræ (from the second to the ninth) with portions of their contiguous ribs. The lungs are expanded so as to show their proper relations posteriorly.

1. The body of the first dorsal vertebra.
2. The thoracic duct, winding across the œsophagus to enter the superior mediastinum.
3. The upper portion of the left lung.
4. The descending portion of the arch of the aorta, overlapped above by the left lung.
5. The vena azygos major, crossing to the right of the œsophagus.
6. The œsophagus, distended.
7. The vena azygos minor.
8. The thoracic aorta.
9. The thoracic duct, after its entrance into the thorax from the aortic opening.
10. The upper surface of the left arch of the diaphragm.
11. The spine of the ninth dorsal vertebra.
12. The upper portion of the right lung.
13. The vena azygos major entering the superior vena cava.
14. The left auricle of the heart.
15. The lower portion of the right lung.
16. The base of the left ventricle of the heart.
17. The inferior vena cava.
18. The upper surface of the right arch of the diaphragm.



... from nature by George McClellan, M.D.

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shows that both lungs are here somewhat palm-shaped, with their bases toward the spine and their narrower portions toward the sternum.

Each lung is divided into an *upper* and a *lower lobe* by a *great fissure* which commences behind about seven and one-half centimetres, or three inches, from the apex, opposite the fourth dorsal vertebra on the right and the third on the left, and descends obliquely forward to the junction of the seventh rib with its cartilage on the right, and opposite the sternal end of the sixth rib on the left. There are, however, many alterations in the relative positions of the fissures, and their terminations cannot be foretold. There is generally a deep notch in the anterior edge of the left lung over the pericardium where it is in relation to the apex of the heart (Plate 30, No. 42), and occasionally the right lung is similarly notched about the cartilage of the fourth rib (Plate 29). The right lung is subdivided by a secondary fissure which commences about opposite the sixth rib, near its angle, and extends usually to the cartilage of the fourth rib and thus marks off a *middle lobe.* The lower primary lobes of both lungs are the largest, and they chiefly constitute the posterior portions, whereas the anterior portions are mainly formed by the upper lobes. Occasionally the left lobe has a semblance of a secondary fissure, and occasionally also the secondary fissure in the right lung is undeveloped.

The convex outer surfaces of the lungs are free and moulded to the interior of the thoracic walls, and the concave inner or mediastinal surfaces are connected to the heart and the trachea by the bronchial tubes, with their vessels, nerves, and lymphatics, and by the pulmonary arteries and the pulmonary veins. These structures collectively form the *roots of the lungs,* and are held together by areolar tissue, and supported below by reflections of the pleuræ, called the *ligamenta lata pulmonalia.* The roots of the lungs are attached to the bottom of a deep cleft, the *hilum pulmonale,* which is situated a little nearer the posterior than the anterior surfaces and above the middle of each lung. If the thorax be opened from behind by removing the dorsal vertebræ and contiguous portions of their ribs (Plate 39), it will be seen that the vena azygos major arches over the root of the right lung and the aorta over the root of the left lung. Behind the right root are the posterior pulmonary plexus of the pneumo-

gastric nerve and the vena azygos (Plate 37), and behind the left are the descending aorta and the posterior pulmonary plexus of the pneumogastric nerve (Plate 36). In front of each root are the anterior pulmonary branch of the pneumogastric and the phrenic nerve. In front of the root of the right lung is also the superior vena cava (Plate 33).

The *trachea* at the root of the neck, as previously described (page 236), passes deeply from the outer surface in front of the œsophagus to its bifurcation into the right and left bronchi within the superior mediastinum. The bifurcation is about on a level with the body of the fourth dorsal vertebra posteriorly, and opposite the second intercostal space anteriorly. Within the chest the trachea is crossed by the arch of the aorta, the deep cardiac nerves passing between them. The œsophagus projects a little to the left of the middle line at the root of the neck, and is closely connected by areolar tissue to the trachea, which is placed between the upper portions of the two pleuræ. The recurrent laryngeal nerves from the pneumogastric nerves ascend on each side of the neck in the grooves between the trachea and the œsophagus (Plate 39).

The bronchi vary in length, direction, and diameter. The *right bronchus* is about two and a half centimetres, or an inch, in length, and, passing nearly horizontally, enters the right lung about opposite the body of the fifth dorsal vertebra. Its diameter is greater than that of the left bronchus, and, as the ridge of separation between the two bronchi at the bottom of the tracheal tube inclines to the left of the middle line, foreign bodies which may chance to fall down the trachea are more likely to pass into the right bronchus. The *left bronchus* is about five centimetres, or two inches, in length, and descends obliquely to enter the left lung opposite the sixth dorsal vertebra. The left bronchus passes in front of the œsophagus and thoracic duct and under the arch of the aorta (Plate 38). In structure the bronchi resemble the trachea (page 236), the right having from six to eight rings and the left from nine to twelve. At the roots of the lungs the bronchi subdivide into two branches, the *bronchial tubes*, corresponding to the primary lobes of the lungs. The lower branch of the right bronchus sends off a small branch to the third lobe on that side. The right bronchus at the root of the right lung is behind the right pulmonary artery, and

the left bronchus also holds the same relative position, being behind the corresponding pulmonary artery. On both sides the pulmonary veins are in front of the arteries (Plate 41, Fig. 1). Within the lungs the bronchial tubes divide dichotomously into posterior and anterior branches, which again subdivide into lateral branches, and these diverge in all directions throughout the organs until their termination in the *lobules*, where they are known as *bronchioles*. There is no communication between the bronchioles, so that if any obstruction occurs in one branch the air cannot reach the vesicles to which it naturally leads.

The pulmonary and bronchial vessels, the lymphatics and nerves, all accompany the ramifications of the bronchial tubes, and are united to them by connective tissue, the arteries always being behind and the veins in front of the tubes. Within the *structure of the lungs* the tubes cease to have regular cartilaginous rings, circular muscular fibres with patches of cartilage here and there constituting the walls of the branches. They are lined throughout with the mucous membrane continued from the trachea, which is covered with columnar ciliated epithelium. Gradually all traces of cartilage disappear and the walls present irregular dilatations, which commence in pouches surrounding the ultimate tubules. These enlarge in diameter and end as sacculated passages, the *infundibula*, whose walls consist of blind pouches, the *alveoli* or *air-vesicles*. They are surrounded and connected everywhere with an *elastic tissue*, in which there are only slight traces of muscular tissue, and which is derived from the peculiar elastic sub-serous tissue closely investing the surfaces of the lungs beneath the pleura. Upon this elastic tissue the remarkable expansibility of the lungs depends. When the chest is opened the lungs collapse to about a third of their ordinary bulk (Plate 33), in consequence of their elasticity. This elastic tissue is prolonged from the surfaces into the inner structure of the organs, forming numerous angular spaces of various sizes about the alveoli, and called the *pulmonary lobules*. When the lungs are distended, the surface is everywhere marked by polygonal areas, which vary in size at different ages. These areas are mapped out into smaller ones, which are less distinct. They indicate the lobules, which are larger on the surface than in the interior of the lung. After air has once entered into the

lobules it cannot be entirely pressed out, owing to their spongy texture, and any portion of the lung will therefore float on water, but it will sink immediately if inspiration has not taken place, and owing to this property such a demonstration is frequently made use of as a test in medico-legal investigations. It should be remembered that a portion of lung-tissue from which the air has been dispelled by pneumonic exudation will also sink in water. When pressed between the fingers, the escape of air from the lung-tissue produces crepitation. When the air-vesicles are ruptured, the air escapes into the interlobular tissue, producing *pulmonary emphysema*, and if there is infiltration of serum into this tissue it is called *œdema of the lung.* If the lung-tissue is torn, a reddish frothy liquid is exuded, consisting of mucus, air, and blood commingled.

The terminal branches of the pulmonary artery form nets of capillary vessels which accompany the bronchioles in their distribution to the alveoli, where they are covered by epithelium on both surfaces and project into the air-vesicles. The *pulmonary capillaries* are very crowded in relation to the air-vesicles, and the plexus surrounding one air-vesicle is arranged in a single layer and has no communication with that of another vesicle. There are only the delicate wall of the vesicle and the walls of the capillary vessels between the blood and the air, so that the purification of the blood takes place through the absorption of the oxygen and the elimination of carbonic acid and watery vapors. The blood circulating through the capillary plexuses is returned by the *pulmonary veins,* which are very minute at first, but gradually coalesce so that they form branches of increasing calibre and size, which freely anastomose, and, following somewhat the course of the arteries, eventually terminate at the root of each lung in two main trunks which convey the oxygenated blood to the left auricle of the heart. There are no valves in any of the pulmonary veins. Besides the pulmonary system of vessels there are the nutrient vessels of the lungs, derived from the small bronchial arteries. On the right side there is usually one bronchial artery, which arises either from the first aortic intercostal or from the aorta in common with the left bronchial artery. On the left side there are usually two bronchial arteries, both arising from the aorta. They enter at the roots of the lungs posterior to the bronchi, and are distributed

to the walls of the tubules, the larger pulmonary vessels and the pulmonary lymphatic glands, and the inflections of the elastic interlobular tissue.

The bronchial veins mostly empty on the right side into the vena azygos major, and on the left into the superior intercostal vein, although some of them empty their blood into the corresponding pulmonary veins.

The *pulmonary lymphatic vessels* are very numerous, and are arranged in superficial and deep sets, the former forming plexuses over the surface (sub-pleural lymphatics) and throughout the interlobular tissue, communicating with the cavity of the pleura by stomata, and the latter beginning in the mucous lining of the bronchial tubes and accompanying the vessels. The deep lymphatic vessels terminate in the *pulmonary lymphatic glands*, which are situated along the walls of the smaller bronchial tubes and in the angles of their divisions. There are about forty in the right lung and thirty in the left. The efferent vessels from these pulmonary glands join with the superficial lymphatic vessels and end in the *bronchial glands* which are clustered about the roots of the lungs and the lower portion of the bronchi and trachea. The efferent vessels from the bronchial glands communicate with the mediastinal glands, and are generally blackened by the deposition of carbonaceous matter. The right pulmonary lymphatics pass through the intermediation of the mediastinal glands to the right lymphatic duct, and the left pulmonary lymphatics join the thoracic duct.

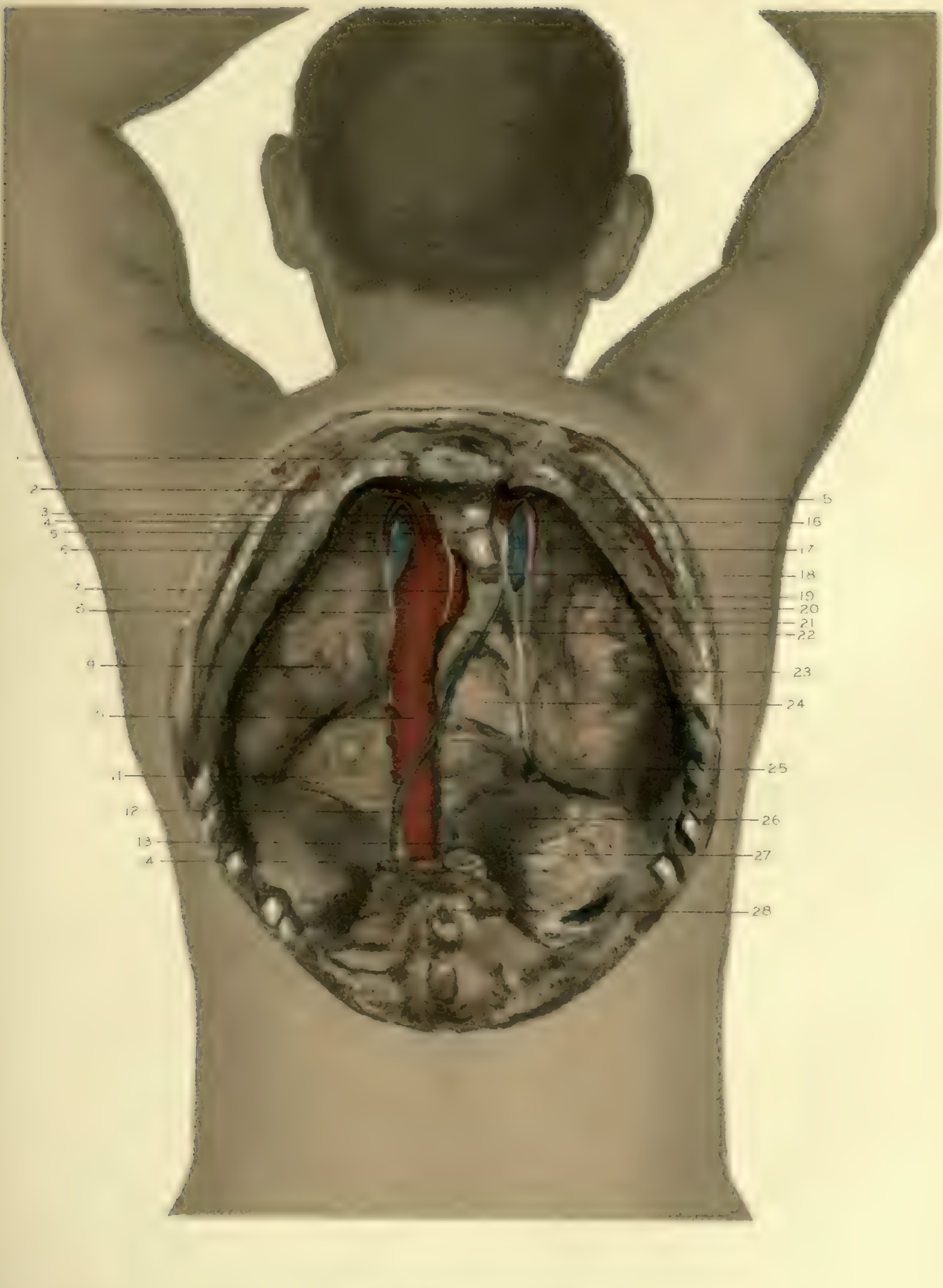
The *pulmonary nerves* are derived from the pneumogastric and sympathetic nerves on each side, which form the anterior and posterior pulmonary plexuses in front of and behind the roots of the lungs. They enter the lungs with the bronchial tubes and accompany their ramifications.

The pericardium, or heart-sac (Plate 34, and Plate 26, Fig. 1), is a dense fibrous pouch which encloses the heart and the portions of the great vessels which enter into and issue from its base. It is broadest below in relation to the diaphragm (page 320), where it is intimately adherent to the middle leaflet of the tendon about the opening for the inferior vena cava and more loosely connected to the muscular part on the left side. Above it passes into the superior mediastinum, enveloping the great vessels and becoming continuous with their sheaths. In this relation it also blends with the downward prolongations of the deep cervical fascia

PLATE 39.

View of the thoracic organs from behind, the dorsal vertebræ (from the second to the tenth) with portions of their contiguous ribs removed. The lungs are displaced to show the relations of the heart.

1. The body of the first dorsal vertebra.
2. The left subclavian artery.
3. The upper (cut) part of the thoracic duct ascending to empty into the left subclavian vein.
4. The left common carotid artery.
5. The left recurrent laryngeal nerve.
6. The left innominate vein.
7. The arch of the aorta.
8. The left phrenic nerve.
9. The left lung pushed aside and forward to show the position of apex of the heart resting on the diaphragm.
10. The thoracic aorta, with origins of the intercostal arteries.
11. The apex of the left ventricle of the heart within the pericardium.
12. The vena azygos minor.
13. The lower (cut) end of the thoracic duct coming through the aortic opening of the diaphragm.
14. The upper surface of the diaphragm on the left side.
15. The innominate artery, bifurcating into the right common carotid and subclavian arteries.
16. The right internal mammary artery.
17. The vena cava superior.
18. The upper (cut) end of the œsophagus.
19. The right pneumogastric nerve.
20. The right phrenic nerve.
21. The vena azygos major, emptying into the superior vena cava.
22. The bifurcation of the trachea into the right and left bronchi.
23. The right lung pushed aside and forward to show the relation of the left auricle of the heart and the arch of the diaphragm on the right side.
24. The left (or posterior) auricle of the heart.
25. The position of the inferior vena cava.
26. The upper surface of the diaphragm on the right side.
27. The lower (cut) end of the œsophagus.
28. The spine of the tenth dorsal vertebra.



Photographed and colored from Nature by George M. Clellan, M.D.

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(page 195), which are continued as dense bands (the suspensory ligaments) upon each side to their attachment at the diaphragm. These connections of the pericardium are of great interest, for if the entire diaphragm descends in respiration it must draw with it the heart-sac and therefore exert more or less strain upon the vessels at the base of the heart. The author inclines to the belief that the central portion or tendon of the diaphragm does not descend, although the lateral muscular portions do. On one occasion, after the excision of the sixth, seventh, and eighth ribs on the right side, he was able to examine the upper surface of the diaphragm during the forced efforts of inspiration under ether, and on another, after the evacuation of the contents of an enormous abscess involving the left lobe of the liver, he could easily introduce his hand into the abscess-cavity and detect the lateral upheaving of the diaphragm and the rapid pulsations of the heart. In the latter case, during the straining of the patient in the act of vomiting it was observed that the diaphragm descended and ascended with spasmodic contractions, but only upon the sides, there being apparently little if any change in the relations of its central tendon. There can be hardly any doubt that the direct connections of the pericardium below with the central tendon of the diaphragm and with the expansions of the deep cervical fascia above play an important *rôle* in maintaining the position of the arch of the aorta, and thus admitting of sudden changes of position without injurious interference with the circulation of the blood at its outset from the heart. The slight descent of the larynx noticeable on deep inspiration is probably due to the expansion of the chest walls and the consequent lateral traction exerted upon the bronchi by the distended lungs. The pleuræ overlap the pericardium in front, the right more so than the left (Plate 26, Fig. 1), and the phrenic nerves descend between them upon each side. Posteriorly the œsophagus is in close relation with that part of the pericardium which encloses the left auricle of the heart. After death the pericardium usually appears to be considerably larger than the heart, but this is due to the empty condition of the left side of the heart. In the healthy state, when the heart is distended, during life, it nearly fills the pericardium, except at the lower part on the left side of the diaphragm, where the sac covers

the apex of the heart and is more or less loose. Although the pericardium is not ordinarily distensible, it may be made in the adult to hold about ten ounces of fluid, and in pericarditis with effusion the accumulation of serous fluid within the sac sometimes reaches a pint or more, which may be drawn off by tapping through the fourth or fifth interspace two centimetres, or about three-quarters of an inch, from either border of the sternum, so as to avoid the internal mammary vessels. The pericardium ordinarily contains several drachms of a clear straw-colored fluid.

The nutrient arteries to the pericardium are derived from the internal mammary, bronchial, and œsophageal arteries, and its veins mostly return their blood to the vena azygos. Its nerves are supplied by the phrenic nerves on both sides. If the pericardium is opened in front (Plate 35) the heart will be exposed glistening with the moist surface of a serous tissue which is reflected over it and the vessels at its base and also lines the fibrous sac. This serous tissue forms a shut sac, and is composed of a parietal layer in contact with the fibrous pericardium and a visceral layer in contact with the heart and interposed between the vessels so as to form a series of pouches. The invagination of the serous layer over the vessels is not always to the same extent, but there are usually seven tubular sheaths thus formed. There is a common reflection around the aorta and pulmonary artery, completely ensheathing them. The superior vena cava is also covered by the serous layer, except where it crosses behind the pulmonary artery. The inferior vena cava is covered only in front as it enters the right auricle directly after passing through the diaphragm. The left pulmonary veins are almost surrounded, and the right are only partially covered. The reflection of the serous layer is very irregular. The pouch which extends upward from the inferior vena cava on the right to the posterior surface of the left auricle is called the *great oblique sinus.* There are other, smaller pouches,—*i.e.*, between the inferior vena cava and the inferior right pulmonary vein, between the pulmonary veins, one on each side, between the upper right pulmonary vein and the superior vena cava, and one between the superior vena cava and the aorta, which, passing under the aorta and pulmonary artery, reaches the left side over the left auricle. This last, from its direction, is called the *transverse sinus.*

Besides these there is a fold between the left pulmonary artery and left pulmonary vein, of crescentic shape, two and a half centimetres, or about an inch, in depth, and two centimetres, or three-quarters of an inch, in length, which is the *vestigial fold*, and is the remains of the left superior vena cava of early fœtal life. These serous reflections enable the heart and the vessels at its base to maintain their freedom of action. That portion of the visceral layer of the pericardiac serous tissue which is closely connected with the intermuscular tissue of the heart-structure is distinguished as the *epicardium*. There are upon the surface many stomata which open from the plexus of lymphatic vessels, especially along the auricular margins. This layer also contains the nutrient vessels and nerves, which are usually associated with more or less fat along the grooves and deeper parts of this tissue. Even in health the amount of fat deposited upon the heart is often considerable; but this must not be confounded with the more serious condition of fatty degeneration of the muscular tissue.

The heart, as it appears upon opening the pericardium (Plate 35), is conical in form, and its surfaces are generally convex, with the exception of that portion which rests upon the pericardium where it is attached to the central tendon of the diaphragm, and which is flattened. It is situated obliquely as regards the middle line of the chest. Its base, to which the great vessels are attached, is directed upward and backward to the right side, where it is held firmly in relation to the spine between the fifth and ninth dorsal (thoracic) vertebræ by means of the dense cervico-thoracic fascia, which blends with the pericardium at the roots of the great vessels. Elsewhere the heart is free within the pericardium, and its apex is directed downward and forward to the left side, where during life it generally beats in relation to the interval between the fifth and sixth costal cartilages. The anterior surface of the heart consists mainly of the right auricle and right ventricle, which are brought into view when the pericardium is opened in front. The termination of the superior vena cava is also thus exposed as it enters the right auricle above, at the side of which is the ascending portion of the aorta curving upward and backward over the pulmonary artery, the root of which is over-lapped by the appendix of the left auricle. Below the latter are the

branches of the left coronary artery passing toward the apex of the heart in the groove between the left and right ventricles. On the right side the right coronary artery issues from beneath the appendix of the right auricle, which overlaps the root of the aorta. The apex is formed by the left ventricle, which projects a little beyond the right, so that normally its beat is felt against the chest wall. The posterior surface of the heart is formed chiefly by the left auricle and the left ventricle (Plate 43, Fig. 3).

As the relative position of the heart to the walls of the thorax is chiefly of value with reference to the normal location of the cardiac valves, it is thought best here to refer to the anatomy of the heart removed from the body (Plate 43), in order that a clearer idea may be obtained of the topographical survey of its relations *in situ*. The exterior of the heart presents more or less defined grooves which indicate the division of its interior into the four compartments called the auricles and ventricles. The *auriculo-ventricular groove* passes obliquely around the heart between the auricles and the ventricles. The *interauricular groove* separates the two auricles, and the *interventricular groove* separates the two ventricles, the anterior portion of the latter beginning under the left auricular appendix and ending to the right of the apex. The nutrient vessels, nerves, and lymphatics to the heart are chiefly lodged in these grooves embedded in fatty tissue beneath the epicardium, as already mentioned (page 275). The *right coronary artery* arises from the aorta upon the right side just after it issues from the heart-structure, and, passing between the pulmonary artery and the right auricle in the auriculo-ventricular groove, distributes branches to the contiguous vessels and portions of the right auricle and ventricle. The *left coronary artery* arises from the back of the aorta, a little higher than the right, and, passing between the pulmonary artery and the left auricle in the auriculo-ventricular groove, gives off several large branches which occupy the interventricular grooves and anastomose freely with the branches of the right coronary artery upon the outer surface. Within the substance of the organ the minute divisions of the coronary arteries terminate in capillary plexuses which empty into comparatively large venous radicles. It is an interesting fact that the

origin of both coronary arteries is *above* the free borders of the aortic semilunar valves, the right being from the anterior sinus of Valsalva and the left from the left posterior sinus, so that there is a steady passage of the blood through them. The *coronary veins* receive their blood from the cardiac veins, which accompany the arteries and are provided with single valves where they are joined by their tributaries. They all end in the *coronary sinus*, which is two and a half centimetres, or about an inch, in length, situated at the back part of the auriculo-ventricular groove, and opens into the floor of the right auricle between the opening of the inferior vena cava and the auriculo-ventricular orifice. At its entrance into the auricle it is guarded by the *coronary valve*.

The shape of the heart varies during life, according to its dilatation or *diastole*, and its contraction or *systole*, but its vertical measurement is not altered by its action. The dimensions of the heart naturally vary with the age, sex, and general development of the individual. The average measurement of the heart of a well-developed adult male is twelve and a half centimetres, or about five inches, in length, from the base to the apex, eight and three-quarter centimetres, or three and a half inches, across the base, and six and a half centimetres, or about two and a half inches, in thickness, between the anterior and posterior surfaces. As a rule, the dimensions of the heart increase up to the age of fifty, and subsequently gradually diminish. The weight is generally about ten ounces in the male, and eight in the female, but depends upon the size and general condition of the body. The right border (*margo acutus*) is sharp and directed obliquely downward, while the left border (*margo obtusus*) is thick and rounded and directed obliquely upward. From the front of the right auricle a small pouch projects about the root of the aorta, which is called, from its resemblance to the ear of a setter dog, the *appendix auriculæ*, and from the upper side of the left auricle a similar appendix extends over the root of the pulmonary artery. When the adult heart is opened so as to display the interior of its cavities (Plate 43, Figs. 2 and 4) it appears to be a double hollow muscular organ, so constructed that each half, separated from the other by a septum, fulfils the function of a pump, for the propulsion of the blood in its circulation. The right half of the heart propels the venous blood to the

lungs, the left propels the arterial blood throughout the body. Each half consists of two cavities, the auricle and the ventricle, communicating by an opening, the *auriculo-ventricular*, which is peculiarly guarded by valves. The auricles are the receptacles of the blood, and are provided with comparatively thin fleshy walls, which are always slightly thicker in the left than in the right. The ventricles, on the other hand, are composed of stout muscular walls adapted to their purpose of forcing outward the blood received from the auricles, their thickness being proportioned to the effort required of them. The left is therefore naturally thicker and stronger, as it distributes the arterial blood throughout the system, while the right sends the venous blood to the lungs. The *right auricle* consists of a main cavity, the *atrium* or *sinus venosus*, out of which extends the pouch called the appendix. When the anterior wall is removed the interior is exposed smooth and glistening, because it is lined with a delicate serous membrane, the *endocardium*, which is continuous with the serous coat of the vessels opening into the auricle, and through the opening into the ventricle below with the inner lining of the pulmonary artery. The *opening of the superior vena cava* is in the upper and anterior part of the auricle, about opposite the right auriculo-ventricular opening, so that the current of venous blood which it conveys from the upper part of the body is directed immediately to the ventricle. The orifice of the superior vena cava is the only large cardiac opening without a valve. The *opening of the inferior vena cava* is in the lowest part of the auricle, and, owing to the slight curve which the vessel takes after passing through the diaphragm, the venous blood which it returns from the lower part of the body is directed toward the oval depression, the *fossa ovalis*, in the auricular septum. The fossa ovalis indicates the position of the *foramen ovale*, which during fœtal life allowed the blood from the inferior vena cava to pass through into the *left* auricle. At that period this course of the blood was greatly assisted by the presence of the *Eustachian valve*, which is situated at the right margin of the opening of the inferior vena cava and extends to the front of the *annulus ovalis*, the prominent border surrounding the fossa. In the adult this valve appears as a thin crescentic fold of the endocardium, and often it has dwindled into a

mere rudimentary band, simply indicating its former position. The floor of the fossa ovalis is the thinnest part of the septum between the auricles.

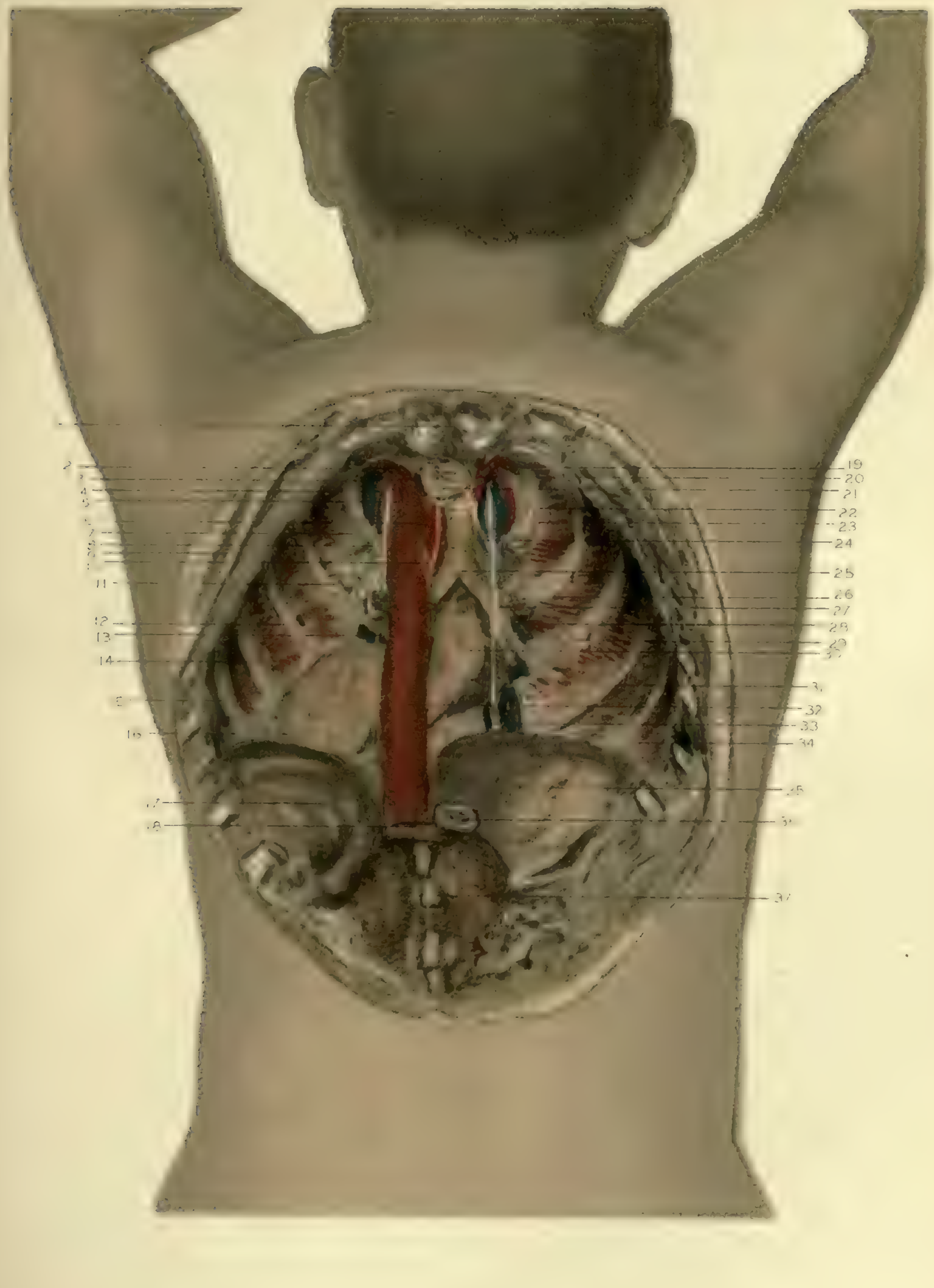
Between the remains of the Eustachian valve and the auriculo-ventricular opening is the *entrance of the coronary sinus*, which is quite large and is guarded by a duplicature of the endocardium, called the *valve of Thebesius*. Besides the sinus there are a variable number of little openings on the posterior wall of the auricle, called the *foramina Thebesii*, which are the minute apertures of little veins coming from the heart-substance. Some of these are impervious, but one, situated on the right of the septal wall, is constant, and known as the *vena Galeni cordis*. Interposed between the openings for the superior and inferior venæ cavæ there is a variable elevation termed the *tubercle of Lower*, which probably aids in the direction of the blood from the superior cava toward the auriculo-ventricular opening in embryonic life. Within the auricular appendix, and to some degree in the lower part of the atrium, there are parallel elevations of the muscular tissue covered with the endocardium, called, on account of their resemblance to the teeth of a comb, *musculi pectinati*.

The *right auriculo-ventricular opening* is of oval form, and large enough to admit three fingers. It is guarded by the *tricuspid valve*, which is named from the usual tripartition of the fibrous tissue of which it is composed, and invested by the endocardium; but this arrangement is often less pronounced than it is generally described as being. When the anterior wall is removed from the *right ventricle*, the objects within its cavity are exposed (Plate 43, Fig. 2). At the upper part there is a smooth passage leading to the opening of the pulmonary artery, called the *infundibulum*, or *conus arteriosus*. From the walls of the ventricle, which are everywhere thicker than those of the auricle, project bands of muscular tissue, the *columnæ carneæ*, of various character and arrangement. Some are short and thick, others are long and narrow. They are either mere ridges projecting from the walls, or constitute little bridges, having both ends attached and being free in the middle. There is usually a band extending from the ventricular septum to the anterior wall, called the

PLATE 40.

The normal position and relations of the thoracic aorta, seen from behind, the lungs being removed to show their roots.

1. The body of the first dorsal vertebra.
2. The left subclavian artery.
3. The left innominate vein.
4. The left internal mammary artery.
5. The left common carotid artery.
6. The arch of the aorta.
7. The left first rib.
8. The left phrenic nerve.
9. The vertebral border of the scapula.
10. The left recurrent laryngeal nerve winding upward round the aorta.
11. The left second rib, near its cartilage.
12. The left third rib.
13. The root of the left lung.
14. The left fourth rib.
15. The left fifth rib.
16. The apex of the left ventricle of the heart (within the pericardium).
17. The upper surface of the diaphragm on the left side.
18. The position of the aortic opening in the diaphragm.
19. The right subclavian artery.
20. The innominate artery.
21. The upper (cut) end of the œsophagus.
22. The right internal mammary artery.
23. The superior vena cava.
24. The right recurrent laryngeal nerve.
25. The trachea bifurcating into the right and left bronchi.
26. The right second rib.
27. The right pneumogastric nerve.
28. The root of the right lung.
29. The right third rib.
30. The left auricle of the heart.
31. The right fourth rib.
32. The thoracic aorta, with the roots of the intercostal arteries.
33. The inferior vena cava.
34. The right fifth rib.
35. The upper surface of the diaphragm on the right side.
36. The lower (cut) end of the œsophagus, where it passes through the diaphragm.
37. The spine of the tenth dorsal vertebra.



[illegible] 1891 by [illegible] McClellan M.D.

...sected, Photographed and Colored from Nature by George McClellan, M.D.

Armstrong & Co. Lith. Boston

moderator, or a number of reticular fascicles taking its place, which prevents the complete reflection of the anterior wall.

The most important of the columnæ carneæ are those which are called the *musculi papillares.* There are three of these, usually well formed, in the right ventricle, corresponding in number to the flaps of the tricuspid valve. They are attached by one end to the walls of the cavity, and at the other terminate in the fine tendinous cords, the *chordæ tendineæ,* which regulate the action of the tricuspid valve. The two largest of the papillary muscles arise from the anterior wall of the ventricle, and the smallest from the septal wall. Occasionally accessory fasciculi are found interposed between the regular muscles and blending with them.

The auriculo-ventricular opening is surrounded by a ring of fibrous tissue which constitutes the base of the valve. The flaps of the valve are thinnest at their contiguous margins where they receive the chordæ tendineæ. Not unfrequently the edges of the flaps are jagged and irregular, and sometimes in the notches between them there are little projecting nodules. The *flaps* are designated according to their relative position as *right* and *left anterior* and *posterior.* The left anterior flap is the largest and freest, while the posterior is the shortest and least movable and is placed toward the septum. The chordæ tendineæ which are attached to the adjacent margins of the right and left anterior flaps and to the notch between them are furnished by the anterior papillary muscle; those to the adjacent margins of the right anterior and posterior flaps and to the intervening notch come from the posterior papillary muscle; and those to the adjacent margins of the left anterior and posterior flaps and to the intervening notch come from the smaller papillary muscle, which is derived from the septal wall and often augmented by independent chordæ which spring from the septum without any papillary muscle. The mode of attachment of the chordæ tendineæ to the flaps is of peculiar interest, as they serve to hold together the flaps of the valve during the systole of the ventricle and thus prevent the blood from regurgitating into the auricle. They are all fastened to the ventricular surface of the valve, and they severally separate into branches which go respectively to the base, middle, and free margins

of the adjacent borders of the flaps as above described. Furthermore, the component fibres of the cords interlace with one another in the fibrous tissue of the valve. In the empty state of the ventricle the flaps appear hanging downward from the auriculo-ventricular opening, but experiment has shown that when the ventricle is full of fluid and is made to contract the fluid catches in the margin of the valve and presses the flaps upward and together, while the chordæ tendineæ act like little guy-ropes and prevent the flaps from turning upward into the auricle. Their proper adjustment and tension are brought about by the action of the papillary muscles, for without them they would be naturally slackened by the contraction of the walls of the ventricle.

At the upper part of the right ventricle the infundibulum leads into the common pulmonary artery, the mouth of which is guarded by three *semilunar valves,* of which one is situated anteriorly to the left and two are placed posteriorly to the right and left. At the upper and posterior surface of each valve the wall of the artery is dilated in a pouch, the *pulmonary sinus* (*of Valsalva*). The valves are formed of fibrous tissue continuous with the fibrous ring surrounding the opening, similar to the construction of the base of the auriculo-ventricular valve, and covered with a duplicature of the endocardium. The free margins of the valves are directed upward toward the lumen of the artery, and are each provided with a crescentic fibrous border, the *lunula,* in the middle of which there is a little blunt nodule of fibro-cartilage, called the *corpus Arantii.* The semilunar valves are readily forced upward by the blood during the ventricular systole, but when the ventricle relaxes the blood in the artery backs up against the valves, and, being received into the sinuses, exerts pressure upon the lunulæ of the valves, so as to bring them together, their closure being completed by the apposition of the nodules.

The *left auricle* is smaller than the right, but, like it, consists of a cavity, the *sinus,* and the auricular appendix. When the posterior wall is removed (Plate 43, Fig. 4) the interior of the sinus is seen to be covered with the endocardium, which is continuous with the lining membrane of all the openings leading in and out of the auricle, and through them with the internal coats of the vessels. Upon the posterior wall of the auricle are the

openings of the pulmonary veins, usually four in number, two on the left and two on the right side, which return the oxygenated blood from the lungs. Sometimes the left pulmonary veins open by one orifice, more rarely by three. They are not guarded by valves. Upon the inter-auricular septum is a depression which indicates the position of the foramen ovale of fœtal life, which before birth admitted the venous blood brought by the inferior vena cava to the right auricle into the left auricle The *musculi pectinati* of the left auricle are fewer and smaller than in the right auricle, and are confined to the lower and back part of the cavity. The *left auriculo-ventricular opening* is of oval shape and a little smaller than the right, and is placed at the lower and anterior part of the auricle. It is guarded by the *bicuspid* or *mitral valve,* which has two flaps, one anterior and to the right, and one posterior and to the left, with little nodules projecting at their notches, called the *nodi valvulæ mitralis.* The right flap is the larger. The interior of the left ventricle presents a close resemblance to the right. Its walls are very thick, especially in their upper portion, where they are also broadest, but they gradually diminish toward the apex. The *columnæ carneæ* are smaller, more reticulated, and more numerous than in the right ventricle. Two large, variably-constituted papillary muscles project from among the columns at the bottom of the cavity, the anterior from the left wall and the posterior from the right. They terminate in *chordæ tendineæ,* which are attached to the flaps of the mitral valve. The construction of the mitral valve corresponds to that of the tricuspid valve, but it is thicker and stronger in all its component parts. The ring of fibrous tissue surrounding the auriculo-ventricular opening, the flaps themselves, and the chordæ tendineæ are all stronger. The latter are similarly attached to the adjacent margins of the flaps, the posterior papillary muscle supplying the adjacent margins on the right, and the anterior papillary muscle furnishing the adjacent margins on the left. They are both reinforced by additional cords from the contiguous portions of the walls with or without muscular origin. The action of the mitral valve is apparently the same as that of the tricuspid,—*i.e.,* to prevent regurgitation of the blood into the auricle during the systole of the ventricle. From the upper and back part of the left ventricle a

smooth surface leads to the *opening into the aorta*, which resembles that of the pulmonary artery, having *three semilunar valves*, with dilatations of the aortic wall (*sinuses of Valsalva*) behind them. The aortic opening is placed in the groove between the two auricles, and it is very close to the left auriculo-ventricular opening, being separated from it only by the larger anterior flap of the mitral valve. In framework and construction the aortic semilunar valves differ from those guarding the pulmonary artery only in being proportionately stronger, to adapt them to the greater work they have to accomplish, consistently with the greater strength of the left ventricle, in sending the arterial blood throughout the general system.

The *structure of the heart* consists of an intricate arrangement of layers of muscular fibres supported upon a framework of fibrous tissue. The latter is disposed in rings about the two auriculo-ventricular, the aortic, and the pulmonary openings, as described in their proper relations. These rings, besides forming the bases for the attachment of the valves, receive at their external circumference the muscular fibres of the walls of the different cavities. The strongest part of the *fibrous skeleton* is in the interspace between the aortic and the two auriculo-ventricular openings. This is triangular, and in some of the lower animals is substituted by a bony nodule, called the *os cordis*. The *muscular fibres of the heart* are peculiar for the comparatively small amount of connective tissue between the component fascicles, which are of the striped variety and very closely associated. They are arranged in layers, whose striæ pass transversely and longitudinally. The fibres of the auricles are distinct from those of the ventricles. They consist of a *superficial layer*, which generally runs across the base of the heart, including both auricles, and a *deep layer*, composed of fibres surrounding the auricular appendix and the entrances of the venæ cavæ on the right auricle, and the auricular appendix and the entrances of the pulmonary veins on the left. The superficial fibres are most marked on the anterior surface, and send a few fasciculi inward to the interauricular septum. The deep fibres also blend with the muscular fibres of the ventricles in front and behind the auriculo-ventricular fibrous rings. The layers of fibres composing the *walls of the ventricles* are very complicated,

and can be satisfactorily studied only after hardening by prolonged boiling, which dissolves the connective tissue. These fibres are independent of the auricles, and are much thicker. They consist of various layers, which for the most part commence from the rings of the fibrous framework above and descend obliquely to the apex of the heart, twisting upon one another in such a manner as to produce what is called the *vortex*, and ascend in the interior of the walls back again to the fibrous rings, sending off in their courses fibres which constitute the columnæ carneæ and musculi papillares. The most superficial layer of the ventricular fibres in front of the heart descends obliquely across from right to left, many of those from the right at the anterior interventricular groove turning inward and intersecting with the fibres in the ventricular septum which arise from the deeper layers. Behind the heart the fibres descend from left to right, and do not enter at the posterior interventricular groove. The deeper layers of fibres which compose the chief bulk of the ventricular walls are arranged in strata, whose fascicles vary in the degree of their obliquity, diminishing from without inward, and interlacing everywhere, so that they present fibres which have been described as making annular or figure-of-eight loops. Some of the deeper layers of fibres do not appear to have any connection with the fibrous rings. The most valuable inference to be drawn from the laborious efforts of investigators, who have attempted to unravel the complications of these muscular fibres, is that the musculi papillares are integral parts of the walls from which they spring, so that they contract simultaneously with them.

The *nerves of the heart* are derived from the pneumogastric and from its recurrent branch, and from the three cervical sympathetic ganglia on both sides (page 219), which form the *great cardiac plexus* in front of and behind the arch of the aorta. This consists of numerous, minute, and delicate nerves, which interlace in every direction with one another, and are known, from their relative position, as the *superficial* and *deep cardiac plexuses* (Plates 36 and 37). In relation to the concavity of the aortic arch there is sometimes found a small ganglion (the *cardiac ganglion of Wrisberg*). Both the superficial and deep cardiac nerves form frequent connections with each other, and thus establish the *pulmonary plexuses*

PLATE 41.

Figure 1.

The thorax of a young female, with the second, third, fourth, fifth, and sixth ribs removed on the left side, and the left lung drawn aside to show the relations of the root of the lung and the apex of the heart to the diaphragm.

1. The manubrium of the sternum.
2. The cartilage of the left second rib.
3. The left internal mammary artery with its two companion veins.
4. The cartilage of the left third rib.
5. The cartilage of the left fourth rib.
6. The cartilage of the left fifth rib.
7. The left first rib.
8. The upper lobe of the left lung.
9. The root of the left lung.
10. The left phrenic nerve.
11. The coronary artery.
12. The lower lobe of the left lung.
13. The apex of the heart.
14. The relation of the phrenic nerve to the apex of the heart.
15. The diaphragm.
16. The left seventh rib.
17. The diaphragm seen between the left eighth and ninth ribs.

Figure 2.

Transverse section through the thorax of an adult male, on a level with the lower borders of the third ribs anteriorly and through the body of the eighth dorsal vertebra posteriorly, seen from below.

1. Section through the gladiolus of the sternum.
2. The right internal mammary vessels.
3. The anterior mediastinum.
4. Section through the right third rib.
5. The superior lobe of the right lung.
6. The right ventricle of the heart.
7. The right auricle of the heart.
8. Section through the right fourth rib.
9. The right phrenic nerve.
10. The middle lobe of the right lung.
11. Section through the right fifth rib.
12. The œsophagus.
13. The vena azygos major.
14. The inferior lobe of the right lung.
15. Section through the right sixth rib.
16. Section through the right seventh rib.
17. The right eighth rib.
18. Spine of the eighth thoracic vertebra.
19. The left internal mammary vessels.
20. The anterior margin of the superior lobe of the left lung.
21. The superior lobe of the left lung.
22. The left ventricle of the heart.
23. The left phrenic nerve.
24. Section through the left fourth rib.
25. Section through the left bronchi.
26. The left pneumogastric nerve.
27. The thoracic duct.
28. The descending aorta.
29. The inferior lobe of the left lung.
30. The body of the eighth thoracic vertebra.
31. The spinal canal with section of the spinal cord.
32. The eighth thoracic vertebra.
33. The left eighth rib.
34. Section through the dorsal muscles.

Fig 1

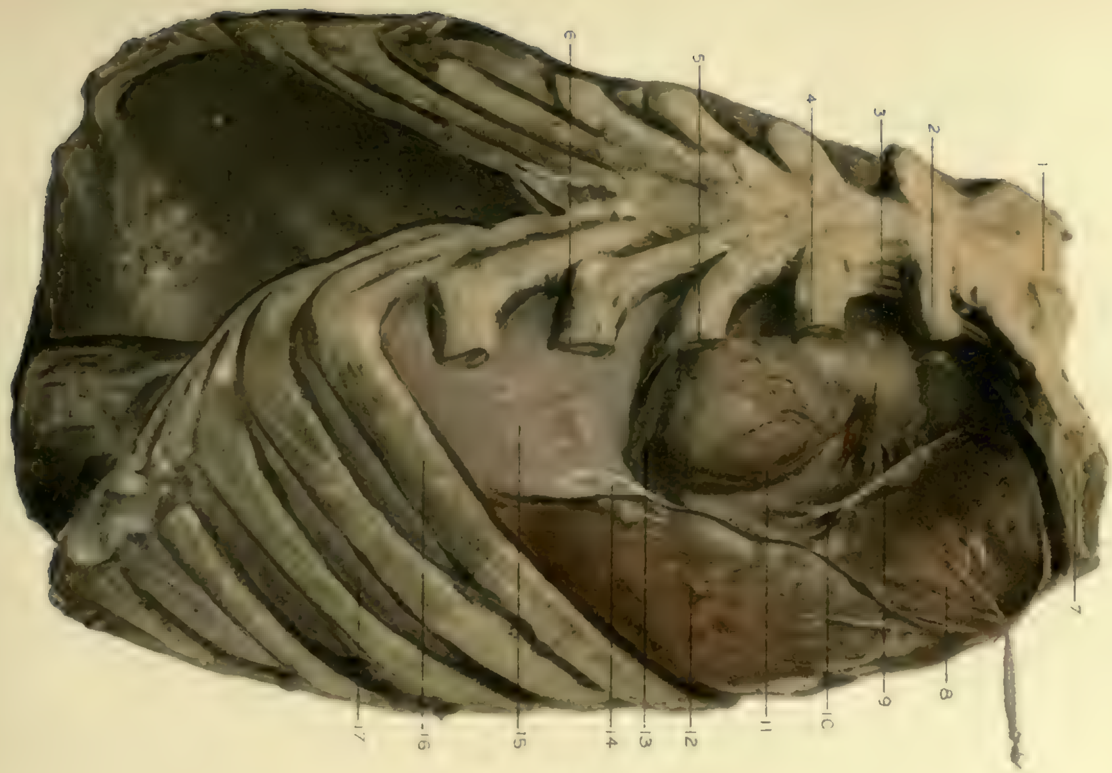


Fig 2

Photographed and drawn from Nature by George McClellan, M.D.

in relation to the roots of the lungs, and the *coronary plexuses.* The branches of the latter respectively accompany the ramifications of the coronary arteries both without and within the substance of the heart. It is said that there are minute *intra-cardiac ganglia,* which possibly preside over the functional contractions of the heart.

The *lymphatic vessels of the heart,* which also occupy for the most part the interventricular grooves with the vessels and nerves, convey their lymph to the glands situated between the aorta and the trachea, and thence pass to the right lymphatic duct and the thoracic duct on either side of the root of the neck.

The *superior vena cava* (Plate 35) is formed by the right and left innominate veins (page 222), which unite opposite the first intercostal space on the right of the border of the sternum, and descends, with a slight inclination backward, to the right auricle, which it enters at its upper and anterior part, opposite the third right costal cartilage. It is six and a quarter centimetres, or about two and a half inches, in length, in the adult, and the lower portion is covered with the pericardium (Plate 34). Above it is covered on the right side by the pleura, between which and the great vein the phrenic nerve passes downward. The superior vena cava is without valves, and receives, besides some pericardiac and mediastinal veins, the *vena azygos major,* which curves downward over the right bronchus above the pericardium (Plate 37, No. 30).

The aorta (Plates 33, 35, 36, 40, 42, and 43) arises opposite the lower border of the *third* costal cartilage, at the upper and posterior part of the left ventricle, near the centre of the heart. Its normal course is very singular, and its shape much resembles that of an old-time shepherd's crook. At its commencement it is expanded into a *bulbous enlargement,* in consequence of the dilatations (the sinuses of Valsalva) opposite the semilunar valves at its cardiac orifice, and proceeds upward about five centimetres, or two inches, and a little to the right of the middle line, as high as the lower border of the second right costal cartilage. This portion is called the *ascending* (or *ventral*) *aorta,* and is enclosed in the fibrous layer of the pericardium. It is in very close relation with the under surface of the sternum, the lower margin of the thymus gland and the right pleural sac

being interposed between them. The bulbous enlargement is covered by the pulmonary artery on the left, being included with it in a common sheath of the serous layer of the pericardium, and by the appendix of the right auricle on the right (Plate 35). The ascending aorta encroaches somewhat upon the superior vena cava, and is in relation posteriorly to the right pulmonary vessels and the root of the right lung. The coronary arteries to the heart are given off from the origin of the aorta, as already described (page 276). Near the termination of the ascending portion the aorta usually presents a dilatation, the *sinus maximus,* which changes the lumen of the vessel in that situation from circular to oval. It is worthy of especial note that the first or ascending part of the aorta is closely covered only by the thin serous layer of the pericardium, which renders an aneurism in this locality very dangerous, in consequence of the easy, rapid distention of the coats of the vessel and the slight hinderance to the escape of the blood into the pericardium.

From the lower border of the second right costal cartilage the aorta passes backward, at first a little upward and to the left, toward the body of the second dorsal vertebra, and then, curving across the trachea just above its bifurcation, it turns downward at its left side as far as the lower border of the fourth dorsal (thoracic) vertebra. This portion is called the *transverse aorta,* or *arch of the aorta.* Its relations are very important and interesting. On the left it is overlapped by the left pleura, beneath which the left phrenic nerve passes, and it is in close proximity to the left pneumogastric nerve, which here gives off the left recurrent laryngeal nerve (Plates 36 and 40), which curves upward under the aorta (page 186). On the right it is in contact with the right pleura, and posteriorly it is very near the trachea, œsophagus, and thoracic duct. From the upper surface of the arch of the aorta the three normal branches arise close together,—*i.e.,* the *innominate artery* (page 221), the *left common carotid artery* (page 223), and the *left subclavian artery* (page 229). Their origins are crossed by the left innominate vein (Plate 35). The orifices of the innominate and the left common carotid, when examined from within the aorta, are separated by merely a sharp edge. The cardiac nerves from the sympathetic and pneumogastric nerves also pass over the arch to their

distribution on the heart (page 219). This portion of the aorta measures four and three-quarter centimetres, or a little less than two inches, in length. The highest point to which its convex surface reaches in a well-formed adult is usually about two and a half centimetres, or an inch, below the upper border of the sternum, and its concavity corresponds with the ridge between the manubrium and the gladiolus; but these points cannot be definitely relied upon, as various factors may tend to raise or lower the arch, and it is subject to modifications owing to interference with its proper development.

There are various irregularities of the great vessels which probably occur more frequently than has been noted, and may be ascribed to either an arrest or a persistence of one or other of the primitive aortic arches of early embryonic life, out of the ordinary order of the human development. Such modifications usually result in transposition of the innominate to the left side or some change in the point of origin of the carotid or the subclavian artery upon one or both sides. Anomalies of the heart and the aorta are extremely rare. It may not be inappropriate to mention in this connection such a case which the author met with in the body of a man aged twenty-seven years, whose death was caused by phthisis. The preparation (Plate 26, Fig. 4) exhibits *no arch of the aorta,* but independent origins of both right and left carotid and subclavian arteries from the top of the descending thoracic aorta, with the heart placed vertically, the position in which it was found within the chest. This disposition of the aortic branches is somewhat analogous to that ordinarily observed in the horse and in the ruminating animals, but it does not appear to have been hitherto recorded as found in man. The heart was found to consist of a single auricle and a single ventricle.

The *common pulmonary artery* (Plate 35), which conveys all the venous blood from the right side of the heart, to be aerated in the lungs, commences at the infundibulum in the upper part of the right ventricle (page 279). This vessel is nearly five centimetres, or two inches, in length, and, as has been already stated, is contained within the sheath of the serous layer of the pericardium, which is common to it and the ascending portion of the aorta. It stands out in front of all the great

cardiac vessels when the heart-sac is opened between the right and left auricular appendages (Plates 33 and 35). Its direction is upward and backward to the concavity of the arch of the aorta, where, in front of the bifurcation of the trachea and on a level with the sixth dorsal vertebra, it divides into the right and left pulmonary branches, which, passing through the pericardium on each side, enter the roots of the respective lungs. The *right branch* is larger and longer than the left, and is separated from the arch of the aorta by the deep cardiac nerves of that side, and as it enters the root of the right lung it is in front of and *below* the right bronchus (page 268). The *left branch* passes in front of the descending aorta and enters the root of the left lung in front of and *above* the left bronchus (page 269). Where the left branch leaves the pericardium there is a short fibrous cord extending backward to the left end of the arch of the aorta, which is the remains of the *ductus arteriosus*, the canal by which, in fœtal life, the blood from the pulmonary artery passed directly into the aorta (page 304). The *pulmonary veins*, which return the blood to the left auricle of the heart after it has been re-oxygenated and transformed into *arterial blood* in the lungs, commence in a net-work of capillary vessels upon the walls of the air-vesicles, where they are continuous with the ultimate ramifications of the pulmonary artery (page 270). They also receive part of the blood distributed by the bronchial veins in the substance of the lungs. They unite at first into single trunks corresponding to each lobule, and these in turn unite to form a trunk for each lobe, so that the right lung has three and the left lung two main efferent vein-trunks. Usually the two upper trunks of the right lung join at its root, although they sometimes remain independent of each other. The right pulmonary veins are somewhat longer than the left, and they all terminate in the posterior wall of the left auricle (page 283), the orifices of those coming from the left lung being closer together and on a lower level than those from the right. The upper one of the right and the lower one of the left are respectively larger (eighteen millimetres, or three-quarters of an inch, in diameter) than their companion veins. Both pairs in the roots of the lungs (page 268) occupy a position in front of the pulmonary arteries, and as they pass

horizontally toward the left auricle they pierce the pericardium, the serous layer of which is reflected over their anterior surface. There are no valves in the pulmonary veins.

As the heart is the central organ of the vascular system, in which, by means of the great vessels at its base, the arteries originate and the veins terminate, the general anatomy of these two classes of the blood-vessels may be here properly considered.

The arteries are comparatively firm, elastic tubes, which commence at the heart in two great trunks, the aorta (page 287) and the pulmonary artery (page 289), the former distributing the arterial blood from the left ventricle throughout the general system, and the latter conveying the venous blood from the right ventricle to the lungs, as described on page 306.

The *systemic arteries* arise from the main branches of the aorta, which are directed to the head and the extremities and to the various organs of the body. The arteries generally pursue the shortest, most direct, and most protected course from their origins to the locality of their distribution, and this is particularly noticeable in the extremities, where they are contiguous to the bones, in the lines of flexure, so that they are less exposed to injury and less likely to be compressed by muscular action. The arteries (except within the tissues of the brain and of the bones) are provided with a special investment of the areolar tissue of the parts in which they are contained, constituting their sheaths, and in particularly exposed situations the superficial arteries are usually further protected by tendinous expansions. They also continue of uniform size until they give off a branch, when they become, as a rule, somewhat smaller in calibre. It has been estimated, however, that the combined capacity of the branches is greater than that of their original trunks, and in consequence there is naturally a diminution in the velocity of the blood-current as it proceeds farther and farther from its source. In certain localities, where the parts are freely movable, the arteries are tortuous, so that they readily accommodate themselves to changes in position and the movements of the soft parts without being subjected to strain. The facial, lingual, and vertebral arteries are examples. Arteries branch in various ways. If they divide

into two equal branches, they diverge at equal angles from the line of the trunk. If the branches are unequal, the trunk is deflected from its straight course to the side opposite that to which the branch is distributed, varying in degree according to the size of the branch. In fact, the branches may be given off at any angle, but they usually proceed at an acute angle from their origin. In their course the smaller arteries frequently communicate with one another, constituting what is called their *inosculation* or *anastomosis.* This arrangement serves to prevent an interruption in the flow of the blood in case of pressure upon one or other of the branches, and is of great value in the establishment of the *collateral circulation* after the ligation of any one of the principal vessels.

In the brain, the retina, and the kidneys the ultimate branches of the arteries are called *terminal* or *end arteries,* because they do not anastomose with one another, and consequently if a supplying artery is blocked by an embolus the area of its distribution is completely destroyed by necrosis.

During life the arteries possess a considerable degree of elasticity and contractility, as is often witnessed in the remarkable manner in which they escape injury in penetrating and incised wounds. In the healthy state the walls of the arteries are capable of withstanding a considerable degree of intravascular tension, and their firmness is conspicuous, for when they are cut across they do not collapse, as the veins do. They appear empty after death, and on this account were originally supposed to contain air. The elasticity of the arteries diminishes with age, and in consequence they often become spirally twisted and tortuous in localities where they are loosely embedded in the tissues. The size of the arteries is proportionate to the amount of blood required by the *physiological actions* of the part which they supply. The larger arteries (eight millimetres, or three-eighths of an inch, in diameter) are attended by a single large vein; the medium-sized arteries (six millimetres, or one-quarter of an inch, in diameter) have one or two accompanying veins, and the smaller (three millimetres, or one-eighth of an inch, in diameter) usually two veins. The *venæ comites* of the arteries are generally included in their areolar sheath, together with the nerve-cord which passes to the same area of distribution as the artery.

The course of the arteries in the extremities is generally along the intermuscular septa, or in the spaces between the superficial and deep muscles, so that a twig issuing among the surface-tissues, if traced backward, serves as a guide to the position of the main vessel. By this means, for example, the anterior and posterior tibial arteries within the deeper part of their course may be easily found; and there is no safer way of reaching the external iliac artery than by following the deep epigastric, or of reaching the axillary artery than by following the acromial. Owing to some localized arrest of development, occasioning dilatations of anastomotic branches and attended by contraction or obliteration of the main trunk, there are frequent *variations* in the arteries, and it often happens that a vessel which is usually small may become abnormally enlarged, so that it is liable to be mistaken for the main artery. It should be remembered also that a small branch arising from a large vessel will always bleed freely, and to an extent out of proportion to its size, so that its hemorrhage requires to be promptly arrested.

The *structure of the walls of the arteries* consists of three chief layers of various formation which are intimately associated with one another. They are called the external, middle, and internal coats, or the tunicæ adventitia, media, and intima. The *external coat*, or *adventitia*, on which the strength and firmness of the arteries mainly depend, is composed of layers of condensed fibro-connective tissue derived from the surrounding cellular tissue and arranged in interlacing bundles, between the meshes of which are lymph-spaces and connective-tissue corpuscles. In the larger vessels, and in the arteries which are loosely connected with their surroundings, as on the face and the mesentery, longitudinal muscular fibres are blended with the other elements of the outer coat, which in the latter case not only renders the mesenteric arteries thicker but enables them to offer support to the parts which they supply, the jejunum and the ileum, and to withstand the constant traction to which they are subjected in the changes of position of the intestines during life. The *middle coat*, or *media*, is the thickest portion of the wall of an artery. It consists principally of unstriped muscular fibres (and therefore is sometimes also called the *muscular coat*), with a variable quantity of elastic connective-tissue fibres.

PLATE 42.

Dissection of the vascular system in a child eight months old, showing the principal arteries and veins in their proper relations and positions.

1. The right temporal artery.
2. The right facial artery.
3. Branch of the right lingual artery.
4. The body of the hyoid bone.
5. The superior, or descending, thyroid artery.
6. The right internal jugular vein.
7. The right common carotid artery.
8. The right pneumogastric nerve.
9. The median nerve of the right arm.
10. The thyroid body.
11. The sternal end of the right clavicle.
12. The axillary artery.
13. The trachea, at the root of the neck.
14. The right subclavian vein, branching from the right innominate vein.
15. The right innominate vein.
16. The right subscapular vessels and nerves.
17. The superior vena cava.
18. The root of the right lung, showing the pulmonary vessels.
19. The right auricle of the heart.
20. The anterior coronary artery and veins.
21. The under surface of the diaphragm, showing the right phrenic arteries.
22. The inferior vena cava.
23. The right kidney, opened, showing the renal vessels.
24. The right spermatic vein, emptying into the inferior vena cava.
25. The superior mesenteric artery, drawn to the right side.
26. The right ureter.
27. The right common iliac artery.
28. The right spermatic artery.
29. The right internal iliac artery.
30. The inferior mesenteric artery.
31. The right circumflex iliac artery.
32. The right anterior crural nerve.
33. The right femoral vessels, passing under Poupart's ligament.
34. The right spermatic cord.
35. The sartorius muscle.
36. The femoral artery, passing into Hunter's canal.
37. The gracilis muscle.
38. The insertion of the sartorius, gracilis, and semitendinosus muscles.
39. The left temporal artery.
40. The left facial artery.
41. The left lingual artery.
42. The left sterno-mastoid muscle.
43. The left pneumogastric nerve.
44. The left internal jugular vein.
45. The left common carotid artery.
46. The left superior thyroid artery.
47. The median nerve and brachial artery of the left arm.
48. The axillary artery, surrounded by the cords of the brachial plexus.
49. The sternal end of the left clavicle.
50. The left carotid artery.
51. The left innominate vein.
52. The left subclavian artery.
53. The left subscapular vessels and nerves.
54. The arch of the aorta.
55. The root of the left lung, showing the pulmonary vessels.
56. The posterior coronary artery.
57. The apex of the heart.
58. The left phrenic artery, on under surface of the diaphragm.
59. The abdominal aorta.
60. The cœliac axis.
61. The left kidney, opened to show the renal vessels.
62. The left spermatic vein, emptying into the renal vein.
63. The left ureter.
64. The left spermatic artery.
65. The left internal iliac artery.
66. The inferior mesenteric artery.
67. The sigmoid flexure of the colon, drawn aside.
68. The superior hæmorrhoidal, or rectal, artery.
69. The left circumflex iliac artery.
70. The bladder.
71. The left anterior crural nerve.
72. The left femoral vessels.
73. The left spermatic cord.
74. The left adductor longus muscle.
75. The left sartorius muscle.
76. The left gracilis muscle.
77. The anastomotica magna artery.

N. B.—The preparation from which the photograph for this plate was taken is remarkable because it is an actual demonstration of the circulation of the blood. The injection, a solution of wax in ether, was introduced into the right common carotid artery beneath the lobe of the thyroid body, and, having passed through the capillaries, filled the veins. There is some probability that the foramen ovale had remained unclosed, which would have contributed to complete the venous injection. The ductus arteriosus was obliterated.

They are arranged for the most part circularly, except in the smallest arterioles, where they are spiral. The proportion of the elastic tissue apparently diminishes with the size of the artery, while the converse is true with regard to the muscular tissue, so that the smaller vessels possess greater contractility relatively to the larger. Connective tissue also enters into the construction of this coat in the larger vessels, and many of the latter are provided with an external elastic lamina (Henle). The muscle-fibres in the middle coat of the large arteries are irregular and both oblique and longitudinal, while in the small arteries they are more uniform and exhibit under the microscope longitudinal striæ each containing an elliptical nucleus. The *internal coat*, or *intima*, is very delicate and thin, and composed of an intermixture of elastic and fibrous tissue arranged in several layers. The amount of elastic tissue also varies with the size of the vessel, being in the smallest merely a single layer. The internal surface of the intima consists of the transparent membrane, the *endangium*, which closely resembles the serous membranes in character and is continuous with the endocardium of the heart. The endangium has been demonstrated to be constituted of two layers, called the *endothelium* and the *membrana propria*. The former consists of a single stratum of transparent fusiform cells having a central nucleus and arranged parallel to the course of the vessel. The latter consists of interlacing connective-tissue fibres containing branching corpuscles. The amount of muscle and elastic tissue in the walls of certain arteries is variable irrespective of their calibre, as it has been proved that the carotid and axillary arteries are provided with more elastic tissue in their middle coats than the femoral, which has a greater quantity of muscle-fibre.

Upon the application of a ligature to an artery in the healthy state the internal and middle coats are completely broken, so that they retract, while the external coat is puckered up.

The arteries are without valves.

The veins possess much thinner walls and are generally larger in calibre than the arteries. They return the venous blood from the system by means of the superior and inferior venæ cavæ (pages 287 and 306), and from the walls of the heart by the coronary sinus (page 277), to the right

auricle, and the arterial blood from the lungs by the pulmonary veins (page 290) to the left auricle. The *systemic veins* are more numerous than the arteries, and their combined capacity is greater. They originate in radicles, which receive the blood from the capillaries everywhere in the tissues, and are generally arranged in plexuses at their commencement. From these plexuses branches are given off which unite into trunks, which are constantly increased in size by being joined by tributaries in their course toward the heart. They consist of two chief divisions, the *superficial* and the *deep veins*. The former are placed between the layers of the superficial fascia beneath the skin, and the latter accompany the arteries, being known as the *venæ comites*, or *satellites*. The largest arteries and their largest branches are usually accompanied by a single vein, but the medium-sized and smaller arteries have two veins, which are enclosed in their common sheaths, as previously described (page 292). In certain regions, as in the brain, the spinal canal, and the liver, the veins do not accompany the arteries; in others, as in the head and face, they pursue a more direct course than the arteries. The veins communicate or inosculate much more freely than the arteries do, even among those of large size. This is conspicuous with the superficial veins, which form a network over the whole body. The intercommunication of the superficial veins with the deep is especially noticeable at the flexures of the joints, where the motions would otherwise be liable to offer impediment to the flow of the blood. This is also markedly the case in the neck and within the cranium, where any obstruction to the venous system would be followed by a dangerous stasis.

The veins of the dura mater within the head are called the *sinuses*, which are formed by the splitting of that membrane and lined by epithelium (page 18). In certain localities where veins are contained within masses of areolar tissue and enveloped in a dense fibrous membrane, they may anastomose, but as their walls are imperfect they allow their blood to escape into the surrounding trabeculæ or spaces and thus form *erectile tissue*, as in the *corpora cavernosa penis*. The veins offer very many anomalies, but there is always a noticeable fact regarding them,—*i.e.*, that where a vein is unusually small there is a compensating enlarge-

ment in an adjoining or neighboring vein. Such a variation is commonly noticed between the external and anterior jugular veins (page 192). The *structure of the walls of the veins* is composed, like that of the arteries, of three coats, but taken together they are less uniform and thinner than the arteries, although they are more intimately connected. They possess considerable strength, however, and the walls of the superficial veins are generally thicker than the deeper ones. It is very difficult to separate the *external* and *middle coats.* The former consists chiefly of a compact layer of fibro-connective tissue blended with meshes of elastic fibres. The latter is mostly made up of irregular circular bands of unstriped muscular tissue, also held together in meshes of elastic fibres. The amount of fibro-connective and muscular tissue varies in the veins of different parts, and the two tissues hold variable proportions to each other in the outer and middle coats. In the great jugular and innominate veins at the root of the neck there is a deficiency of muscular tissue. In the Haversian canals of the bones the walls of the veins consist only of fibrous tissue lined with endothelium.

The *internal coat,* or *intima,* of the veins is very similar to that of the arteries, consisting of a very delicate elastic membrane, having upon its internal surface an endothelial lining and a substratum of striated connective tissue, often containing muscle-cells. One of the most important peculiarities of the veins is the development of *valves* from their internal coats in certain localities, which prevent regurgitation of the blood and therefore assist its passage toward the heart. They usually occur in pairs, placed opposite each other in the course of a vein, but are single at the orifices of the branches. The valves are not found in all veins, but they are most numerous in the superficial veins of the extremities, especially the lower, where they often appear like knots through the skin in varicosed conditions. They consist of crescent-shaped flaps composed of the inner coat, like little pockets. They are attached with their convex border to the sides of the vein and their free concave margin directed in the proper course of the blood, so that if this is interfered with by pressure and a reflux occurs the pockets become filled and close the lumen of the vein by their distention. The valves are not always equally developed,

as on several occasions the author has found it possible to throw an injecting material into the radicles of the hand or foot through the main venous channel of the limb: in two instances a solution of wax in ether was thus made to traverse the capillaries and fill the arteries.

The relative position which the main arterial and venous trunks bear to one another throughout the body follows the rule already mentioned (page 222), that above the diaphragm the veins are superficial to the arteries, while below the diaphragm the arteries are superficial to he veins, with the single exception of the renal veins.

The capillaries are the fine hair-like vessels which serve as the secret communications by which the blood passes continually from the arteries into the veins throughout the tissues of the various organs of the body. They are so minute that they can be seen only with the microscope, and so fine that it is necessary to rupture several of them to get a drop of blood. Although generally very numerous, they vary in number in the different tissues according to their requirements for nutrition, being most abundant in the tissues or organs where the greatest degree of vital activity exists. They are not found in the cartilages, epithelium, or epidermis. Ordinarily they are arranged in a system of net-works, which vary in the size of their meshes in different localities. They are very close in the lungs, in the gray substance of the brain and spinal cord, in the mucous membranes generally, and in the muscular and adipose tissues. In the dermis and choroid coat of the eye the net-work of capillaries is exceedingly fine and close. In the fasciæ, however, and the aponeuroses, tendons, and ligaments, the capillary meshes are wider, the vessels themselves being fewer. They are variably arranged to conform with the structure of the tissues which they occupy. This is noticeable especially in the lungs in relation to the lobules, and in the papillæ of the skin or the villi throughout the intestinal canal. In their simplest form the capillaries may be considered as composed only of the delicate endothelial lining of the arteries or veins with which they are continuous. They are both elastic and contractile, so that they differ in calibre under different conditions. Under the influence of chemical reagents their walls have been shown to have a cellular construction, with the cells arranged longitudinally to the

axis of the vessel. The cells contain an oval nucleus, and they are held together by what is termed "intercellular cement," which is marked at intervals by fine dots. During the state of inflammation the capillaries become distended, and the intercellular cement in the localities of these dots yields, occasioning small openings in the walls, the *stomata*, through which the white blood-corpuscles show a tendency to escape into the interspaces among the tissues. This is an important characteristic of these vessels, as by its means the elements of nutrition in the processes of growth, repair, and performance of function are imbibed and eliminated. When the capillaries in the web of a frog's foot or in the mesentery of a snake are examined under the microscope, they appear as transparent tubes containing a clear fluid (*liquor sanguinis*), which moves more slowly along the walls of the vessels, being retarded by friction, than in the centre, where the corpuscles are arranged in a column and are swept onward with greater rapidity. It follows from the resistance offered by the increased wall-area of the capillaries, as well as by the minuteness of their lumina, that the blood circulates through the capillaries much more slowly than it does in the large arteries. In some tissues the blood-vessels, before they terminate in capillaries, divide into peculiar tufts of minute anastomosing vessels, such as are seen in the glomeruli or Malpighian corpuscles of the kidney. In others the separate arterial stems and venous radicles form a net-work before they break up into capillaries, and thus constitute the different forms of *rete mirabile*, such as occur in the choroid tela and velum interpositum of the brain. The walls of all the larger arteries and veins are provided with arteries and veins of their own, the *vasa vasorum*, which are derived from and terminate respectively in the neighboring vessels. It is evident to the naked eye that such vessels are furnished to the external coats of the large vessels, and it is asserted that the microscope has revealed that there are capillary vessels in relation also to the middle coat. Lymphatic vessels appear, as already stated, in and around the external coats, and about the largest vessels they establish plexuses.

The arteries and veins are also supplied with nerves, the *vaso-motor nerves*, which form plexuses in the muscular or middle coats, more especially of the arteries. They have been shown to preside over the

contractility and dilatability of the vessels, and explain many of the physiological phenomena, as in pallor or blushing, and the changes in local temperature, owing to their influence upon the degree of blood-pressure. The vaso-motor nerves, although apparently derived as fibres from the sympathetic ganglia in the various regions of the body, have been demonstrated by experiment, in many instances, to arise originally from the nerves of the spinal cord. The so-called *inhibitory* or repressing effect manifested in the physiological action of certain drugs is probably ascribable to them. These nerves are now considered as consisting of two distinct sets of fibres, which from their opposing influences are called *vaso-constrictor* and *vaso-dilator nerves.* The marvellous rapidity with which the secretion and excretion of certain organs are performed, and the regulation of the distribution of the blood by which the various physiological processes of digestion are determined, can be understood only by taking into account the controlling influence of this special division of the intricate nerves, composed of fibres from the sympathetic and fibres from the spinal nerves combined, and probably presided over by some special centre in the floor of the fourth ventricle of the brain.

The blood is the viscid, red-colored, opaque, alkaline fluid which circulates throughout the vascular system, and the function of which is to furnish the nutritive material to all the tissues and organs of the body, and to eliminate from them many of the elements of waste which are capable of being revivified and used over again. The color of the blood varies according to the conditions under which it is seen, and in the different sets of vessels in which it flows, being bright red in the arteries, and bluish-black or purple in the veins. These changes of color are due to the amount of oxygen which is in combination with the *hæmoglobin*, the coloring-matter of the blood. The blood has a saline taste and a peculiar odor. Its material is in a continual state of change and motion, the degree of the latter being regulated by the influence of the vaso-motor nerves and the calibre of the vessels in which it is contained.

The blood consists essentially of cellular elements, the *corpuscles*, and an intercellular substance, the *plasma*. The corpuscles are of two kinds, the *white*, or *leucocytes*, which are variable in number in different parts

and in different conditions of the individual, and the *red corpuscles*, which in health always greatly outnumber the white and give to the blood its characteristic color. The *leucocytes* are colorless, nucleated cells, which under the microscope show amœboid motions. The *red corpuscles* are uniform, homogeneous, flattened circular disks, concave upon both surfaces and without nuclei. There are also in the blood a quantity of minute oval disks, called *blood-plates*, and numberless granules, *hæmatoblasts*. The *plasma* is a clear, colorless, alkaline fluid, which is capable of transudation through the walls of the capillary vessels into the surrounding cellular spaces of the connective tissue. These spaces are now called *lymph-paths*, because the lymph is formed within them as the result of the combination of unused plasma and waste tissue-cells. The lymphatic system of vessels is described with the lacteals, in connection with the anatomy of the intestinal canal, in Vol. II.

When fresh blood is examined at the temperature of the body, the *white corpuscles* are seen to change slowly their shape and position, resembling in many respects the microscopic animalcule the amœba. This power of *amœboid movement* enables the white corpuscles under certain influences to pass out with the plasma into the cellular spaces; and hence these corpuscles are also known as the *migratory cells*. The white corpuscles are in fact derived from the lymph, and are supposed to be the source of the red corpuscles; but this has not yet been satisfactorily established. The *red corpuscles* in fresh blood exhibit a remarkable tendency to pile themselves together like little rouleaux of coin. The *plasma* consists chiefly of a permanent liquid, the *serum*, which is a straw-colored fluid, and of certain elements called fibrin-factors, *fibrinogen* and *fibrino-plastin*. When the blood is withdrawn from the body and at rest, there is apparently a ferment formed from the breaking down of some of the white corpuscles, which occasions the union of the fibrin-factors into a clot, or coagulum. The *serum* is an albuminous solution containing salts, fatty matters, sugar, etc., and readily coagulable by heat. The blood also contains in solution oxygen, carbonic acid, and nitrogen gases. The *hæmoglobin*, or coloring-matter, belongs to the red corpuscles, and has a remarkable affinity for oxygen, which it absorbs when

PLATE 43.

Figure 1.

The front view of the heart removed from the body, with the roots of the great vessels arising from the aorta.

1. The trachea.
2. The ima thyroidea artery.
3. The right common carotid artery.
4. The right subclavian artery.
5. The innominate artery.
6. The superior vena cava.
7. The ascending portion of the arch of the aorta.
8. The right coronary artery.
9. The right auricle.
10. The appendix of the right auricle.
11. The left subclavian artery.
12. The left common carotid artery.
13. The transverse portion of the arch of the aorta.
14. The descending portion of the arch of the aorta.
15. The common pulmonary artery.
16. The appendix of the left auricle.
17. The left coronary artery.
18. The right ventricle.
19. The left ventricle.
20. The apex of the heart.

Figure 2.

Section of the *right* auricle and ventricle to show the interior of their cavities.

1. The ima thyroidea artery.
2. The right common carotid artery.
3. The right subclavian artery.
4. The innominate artery.
5. The ascending portion of the arch of the aorta.
6. The superior vena cava.
7. The foramina Thebesii.
8. The opening of the vein of Galen.
9. The annulus ovalis.
10. The fossa ovalis.
11. The tubercle of Lower.
12. The Eustachian valve.
13. The orifice of the coronary vein.
14. The musculi pectinati.
15. The inferior vena cava.
16. The right common carotid artery.
17. The right subclavian artery.
18. The transverse portion of the arch of the aorta.
19. The descending portion of the arch of the aorta.
20. The appendix of the left auricle.
21. The pulmonary artery laid open.
22. The semilunar valves.
23. The cut edge of the right ventricle.
24. The anterior musculus papillaris.
25. A bristle passed through the right auriculo-ventricular opening.
26. The chordæ tendineæ.
27. The inter-ventricular septum.
28. The columnæ carneæ.
29. The apex of the heart.

Figure 3.

The posterior view of the heart in relation to the thoracic aorta.

1. The left common carotid artery.
2. The left subclavian artery.
3. The descending portion of the arch of the aorta.
4. The pulmonary artery.
5. The appendix of the left auricle.
6. The posterior coronary artery.
7. The thoracic aorta.
8. The apex of the heart.
9. The right common carotid artery.
10. The right subclavian artery.
11. The transverse portion of the arch of the aorta.
12. The superior vena cava.
13. The dilatation situated at the entrance of the inferior vena cava into the right auricle.
14. The inferior vena cava.

Figure 4.

The posterior walls of the *left* auricle and ventricle removed to show the interior of their cavities.

1. The aorta.
2. The pulmonary artery.
3. The musculi pectinati.
4. The appendix of the right auricle.
5. The anterior flap of the mitral valve.
6. The left coronary artery.
7. A needle passed through the aortic opening.
8. The apex of the heart.
9. The left pulmonary veins.
10. The right pulmonary veins.
11. Openings of the pulmonary veins in the wall of the left auricle.
12. The septum.
13. A bristle passed through the left auriculo-ventricular opening.
14. The appendix of the left auricle.
15. The posterior flap of the mitral valves.
16. The musculus papillaris.
17. The columnæ carneæ.

N. B.—The specimen from which these four plates were taken was the heart of an adult male, perfectly healthy and normal, excepting the little ima thyroidea artery, which arises from the innominate, as seen in Figures 1 and 2.

Fig 1

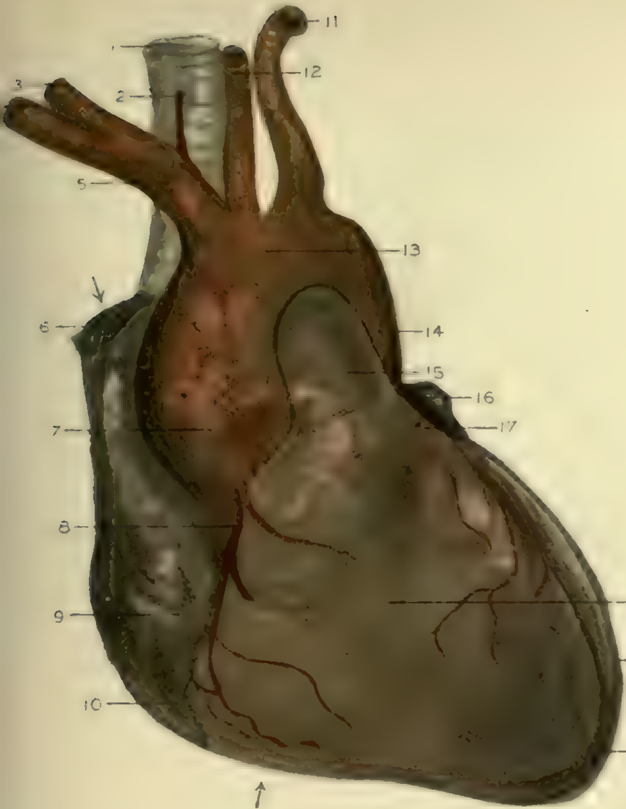


Fig 2

Fig 3

Fig 4

Photographed and Colored from Nature by George McClellan, M.D.

Armstrong & Co. Lith. Boston.

brought into relation with the air-cells of the pulmonary lobules by endosmosis.

The fœtal heart, and the circulation of the blood before birth.—In the early stages of the fœtal formation the heart occupies nearly the whole of the thoracic cavity, and, comparatively speaking, is much larger than it is subsequent to birth. The auricular portion exceeds the ventricular, and the right auricle is more capacious than the left, the right ventricle being also smaller than its fellow. The organ is placed vertically within the thorax in its early stages. Just before birth, however, these peculiarities disappear, and the ventricular portion becomes the larger, the left having the thicker walls, and the whole organ rapidly approaches its normal condition for life. The internal structure of the *fœtal heart* is different from that of the adult chiefly in having an oval opening (*foramen ovale*) between the auricles, which allows a communication from side to side, and in the large size of the *Eustachian valve* (page 278), which directs the blood from the inferior vena cava through the foramen ovale. The latter generally becomes closed within the first week or ten days after birth, but may remain open longer, and in some instances has been found to be slightly pervious at a great age. The Eustachian valve speedily dwindles after the establishment of the function of the lungs and the proper circulation of the blood. Contemporary with these structural alterations changes occur in the great vessels which are requisite for the independent circulation of the blood. The pulmonary artery of the fœtus, after leaving the right ventricle, gives off the right pulmonary branch, and then divides into two other branches, the first of which is as large as the pulmonary artery itself, about twelve millimetres, or half an inch, in length, and directly joins the aorta at the termination of its arch (page 290), while the other goes to the left lung. The connecting branch between the pulmonary artery and the aorta is named the *ductus arteriosus*. It is really the continuation of the pulmonary artery.

The *fœtal circulation* (Plate 26, Fig. 2) consists of the entrance of the *arterial* blood from the placenta into the body of the embryo at the umbilicus, by means of the *umbilical vein*, which ascends to the under surface of the liver.

Within this organ the greater part of the blood first communicates with the branches of the portal vein and with the hepatic veins, and thence passes to the inferior vena cava, but a portion of the blood conveyed by the umbilical vein is conducted by a small vessel directly to the upper part of the inferior vena cava, without passing through the substance of the liver: this vessel is called the *ductus venosus* (Plate 26, Fig. 2, No. 5). The inferior vena cava empties all its blood into the right auricle, whence it is directed by the Eustachian valve through the foramen ovale into the left auricle. From the left auricle it passes through the left auriculo-ventricular opening into the left ventricle, and thence by means of the aorta it is distributed chiefly to the head, neck, and upper extremities. The more immediate supply of pure blood to these parts accounts for their greater proportionate development at birth. The impure blood from the upper part of the body is returned into the superior vena cava, and by it to the right auricle, from which it passes through the right auriculo-ventricular opening into the right ventricle. From the latter it issues by the pulmonary artery, and is chiefly conveyed by its continuation, the *ductus arteriosus* (Plate 26, Fig. 2, No. 13), into the upper portion of the descending aorta, where it mixes probably with some of the blood from the left ventricle passing through the arch of the aorta. From the descending aorta the blood passes through the abdominal aorta into the iliac arteries. The external iliac arteries carry part of this blood to the lower extremities, but most of that in the internal iliac arteries is curiously returned to the placenta by means of the *hypogastric arteries*, which are the continuations of the superior vesical branches of the internal iliac arteries (Plate 26, Fig. 2, Nos. 22 and 24). They pass out at the umbilicus, where, under the name of the *umbilical arteries*, they twine round the umbilical vein in the substance of the cord, and return their impure blood to the placenta to be re-oxygenated. The umbilical vein and the ductus venosus become empty at birth, contract, and are ultimately converted into fibrous cords which occupy the fissure of the ductus venosus of the liver and become its round ligament. They are usually obliterated about the fifth day after birth. The ductus arteriosus and the hypogastric arteries also contract after birth, and become closed, the former usually

within the first ten days, and the latter within the first three or four days. The remains of the ductus arteriosus constitute the *ligamentum arteriosum*, which is attached to the concavity of the aorta at the left end of the arch. The bands resulting from the obliteration of the hypogastric arteries form the lateral false ligaments of the bladder.

The *lungs previous to birth* are quite solid, and are packed into the back parts of the recesses on each side of the thorax. They receive only a slight amount of blood by their proper branches of the pulmonary artery, and return it to the left auricle by the pulmonary veins.

The changes in the heart and vascular system, upon which depends the differentiation of the circulation of the blood before and after birth, are all gradual and commensurate with the processes of development. They are almost completed by the establishment of the function of the lungs when respiration occurs and the connection with the placenta is severed. At birth, the first inspiratory effort appears to be due to the stimulus of the atmosphere upon the surface nerves, which is immediately imparted to the pneumogastric and phrenic nerves, in consequence of which the phenomena of respiration ensue. The first expansion of the lungs is attended with the passage of blood through the pulmonary veins into the left auricle, which exerts a considerable degree of pressure upon the septal valve, so as to bring it in contact with the margin of the foramen ovale, and thus the blood is directed through the left auriculo-ventricular opening into the left ventricle. Coincident with this is the diminution of the tension between the auricles, owing to the arrest of the incoming blood from the umbilical vein, so that there is little obstacle to the blood from the inferior vena cava joining that from the superior vena cava in its passage through the right auriculo-ventricular opening into the right ventricle. The expansion of the lungs in inspiration induces the suction of the blood from the right ventricle into the pulmonary artery and from the left ventricle into the aorta. The passage of the blood through the ductus arteriosus ceases with the determination of the pulmonary circulation and the mechanical influence exerted upon the vessels at the root of the heart through their connections with the deep cervical fascia.

The circulation of the blood after birth, when the organs have

attained their full development, consists in the reception of all the venous blood returned from the body through the venæ cavæ into the right auricle and its passage into the right ventricle, whence it is propelled through the right and left branches of the pulmonary artery into the lungs. Here the blood is subjected to the purifying influence of the air within the lobules (page 269), and then returned by the pulmonary veins to the left auricle. This constitutes the *pulmonary circulation.* The propulsion of the arterial blood from the left ventricle by means of the aorta to be distributed throughout the body, and its return by the capillaries into the veins which conduct it to the right auricle, constitute the *systemic circulation.* The latter, in reality, consists of numerous small circulations everywhere, each of which is made up of supplying arteries, intervening capillaries, and draining veins. In its passage to and from the heart the blood is propelled in a rhythmic current in consequence of the peculiar elastic and muscular contraction of the walls of the ventricles. As it is forced through the openings between the cavities or at the orifices of the vessels leading out of them, every impulse is followed by the closure of the various valves which normally prevent the regurgitation of the blood, and thus characteristic sounds are produced.

The heart-sounds in health consist of a long sound (*lūb*), succeeded by a short one (*dŭp*), which is immediately followed by a pause equal in duration to the second sound; and then the long and short sounds are repeated, and so on. The *first sound* is caused chiefly by the closing of the auriculo-ventricular valves, with the accompanying rush of the blood from the ventricles in consequence of their systole or contraction. This is synchronous with the beat of the apex against the chest wall. The *second sound* is produced by the abrupt closure of the semilunar valves which follows upon the emptying of the ventricles at the close of their contraction, and by the pressure of the blood upon them, which, after it has been driven into the pulmonary artery and the aorta, is forced into the sinuses of Valsalva in its endeavor to return. The degree of the pressure upon the semilunar valves, which is proportionate to the volume of the blood in the great vessels, causes the distinctness with which the second sound is heard, and accounts for what is called its *accentuation.*

Both the right and left ventricles contract and dilate in unison, as both the right and left auricles also do.

The *arterial pulse* is produced by, and coincident with, the ventricular contraction, as may be ascertained upon auscultation and feeling the pulse in any one of the superficial arteries at the same time. In consequence of this the second sound, which is produced by the simultaneous closing of the pulmonary and aortic semilunar valves, may be usually heard with the stethoscope placed over the carotid arteries at the root of the neck, as it is propagated in the blood-current from their origins. If a murmur is detected during the ventricular systole it is probably due to regurgitation of the blood from the pulmonary artery or the aorta, or to some obstruction at one of the auriculo-ventricular openings. If in connection with this there is absence of the second sound over the carotids, aortic regurgitation may be inferred. The prolongation of the first or second sounds, called their *reduplication*, is due to the want of harmonious closure of the flaps of the respective valves producing them. When both the auricle and the ventricle upon one side become dilated from any cause, great tension is exerted upon the fibrous ring to which the base of the auriculo-ventricular valve is attached, and it is rendered "incompetent." The tricuspid valve is peculiarly constructed so that regurgitation may take place through it whenever the right ventricle is in any way embarrassed, and the *third flap* of this valve has on this account been compared to a "safety arrangement," as it provides this means of relief from the strain that would otherwise be exerted upon the pulmonary capillaries. Disease of the tricuspid valve is rare, probably on account of this anatomical provision, but when it allows of regurgitation of the venous blood back into the right auricle it is often associated with a pulse in the jugular veins. This is more especially noticeable in the right jugular vein, as the reflux blood passes more readily into the right innominate vein. What is called the *respiratory pulse* is often observable in the superficial cervical veins, even in health, after rapid exercise, as in dancing, when, during the rapid efforts at expiration and inspiration, and before harmonious respiration is regained, the blood is prevented from emptying itself evenly from the veins into the superior vena cava. As

the left side of the heart is always engaged in forcing the arterial blood throughout the system, it naturally follows that the *mitral valve* is liable to suffer in consequence of over-work. *Mitral regurgitation* is therefore the most frequent of valvular affections, and the murmur which characterizes it necessarily occurs with the ventricular systole. This murmur can be distinguished from aortic regurgitation by not being noticeable in the carotid arteries, but by being more clearly heard over the apex and below the left shoulder-blade, where the left ventricle is nearest the thoracic wall without the intervention of any other portion of the heart.

In order to determine upon a **topographical survey of the chest** (Plate 27) for the clinical study of the relative positions of the important parts of the heart and lungs, it is well to bear in mind certain established facts, and to pay especial attention to the landmarks of this region. There is very little possibility of change in the normal position of the *base* of the heart in the adult, as has been explained (page 273), in consequence of the manner in which the pericardium is attached to the central tendon of the diaphragm below and to the deep cervical fascia above.

The *apex* of the heart, on the contrary, is continually changing its position during life, as it is free within the pericardium, and extends upon the left muscular arch of the diaphragm, which overlies the stomach, so that not only does it naturally accommodate itself to the diaphragmatic movements of respiration, but its freedom is also somewhat interfered with when the stomach is distended. In this connection it should be remembered that the left lobe of the liver overlaps the stomach, even so far as its cardiac extremity, and thus intervenes between the latter and the diaphragm (Plate 29). Distention of the stomach with gas from fermentation in digestion in various dyspeptic conditions is often attended with cardiac disturbance, but this disturbance occurs chiefly through the tension exerted upon the diaphragm and the consequent limitation of the ordinary moving space of the heart within the pericardial sac. Undoubtedly, also, many of the nervous symptoms attendant upon such a condition may be ascribed to the dragging upon the filaments of the pneumogastric nerves which accompany the œsophagus through its proper opening in the diaphragm to their distribution over the stomach (Plate 36). The degree

of displacement of the heart in consequence of distention of the stomach is, however, greatly exaggerated, for, except in very unusual cases, the stomach when distended must enlarge toward its free border at the expense of the abdominal cavity rather than of the thoracic. The anatomy of the diaphragm is described on page 320, but its ever-changing position *at the sides* renders the study of its relations to the adjacent viscera of the thorax and abdomen of peculiar value and interest. After death the diaphragm is usually found arching upward to the fullest extent, owing to the collapsed state of the lungs from expiration; but during life its lateral contractions produce changes which are more apparent than real, for there are alterations in the relative positions of the ribs and sternum above and below, which are coincident and exert a modifying influence on whatever effect it may have upon the neighboring viscera. It should be remembered that the ribs are raised in inspiration and lowered in expiration, and that their relations are thus materially altered. To be of assistance in arriving at any degree of accuracy in observation, these alterations are further to be considered from the standpoint of the individual peculiarities of conformation of the chest; and only by those who are most cognizant of what may be termed the normal changes are the difficulties in the way of mapping out the position of the viscera upon the living body properly appreciated.

The shape of the thorax varies considerably in different individuals. The ribs vary in breadth, as do also the sternum and the intervening cartilages (Plates 27, 28, 29).

The uncertainty attending the many descriptions of the position of the heart within the thorax is mainly due to a want of proper consideration of the relative bearing of this important organ to the general conformation and development of the bony cage which contains it. It should be understood and remembered at the outset of every physical examination that the precise location of the various parts must be settled with exactness upon each individual, and that any standard of measurement can be applied only with latitude. It is easy enough to point out where things ought to be beneath the skin, but to say that they actually are at any one spot, without auscultation and percussion, is not compatible with extensive

observation upon the living or the dead. An allowance should always be made in fixing upon any diagnostic point, but it may be considerably diminished if sufficient attention is paid to the peculiarities of individual conformation.

It has been asserted (page 245) that the ridge between the manubrium and gladiolus of the sternum is the most reliable landmark in the front of the chest. It indicates the position of the sternal attachment of the cartilage of the second rib, and therefore by counting downward on either side the numerical order of the several true ribs may be ascertained. As already stated, the base of the heart may be considered to be anatomically fixed at the junction of the third costal cartilage with the right border of the sternum. This is fortunate for diagnostic purposes, because it assists in determining the localization of the valves of the heart. The apex of the heart in a well-formed adult may be felt beating at each contraction between the cartilages of the fifth and sixth ribs, to the left of the sternum, and about nine centimetres, or three and a half inches, from its middle.

The thorax should give a clear note on percussion, except over the position of the heart, where dulness is elicited. Only a small triangular part of the heart is uncovered by the lungs and pleuræ during full inspiration (Plates 27, 29, and 30), in consequence of the deflection of the left lung from the middle line. This is known as the *area of the greatest cardiac dulness.* The limitations of this area may be approximately indicated by drawing a line from the middle of the sternum opposite the fourth left costal cartilage to the point of junction of the left fifth rib and its cartilage, and from this point horizontally back to the mid-sternal line (Plate 27).

The following survey of the anterior view of the chest is based upon many careful observations upon the living, and it is believed to be verified by the dissections of this region, as represented in Plates 29, 30, 31, 32, 33, 34, and 35. The references throughout the text, as to the position and bearing of the lungs, the heart, and the great vessels, are also the result of personal study.

In the adult, standing erect, with the shoulders squared and the arms at the sides, if the breath is held *upon expiration*, the position of the

valves of the heart may be ascertained, after determining upon the relations of the base and apex of the heart as above described (Plate 27). The *right auriculo-ventricular* or *tricuspid valve* is situated behind the middle of the sternum, opposite the interspace between the right fourth and fifth ribs. The *left auriculo-ventricular* or *mitral valve* is situated just above the cartilage of the left fourth rib, about two and a half centimetres, or an inch, from the border of the sternum. The *aortic semilunar valves* are behind the sternum, between the junction of the cartilage of the left fourth rib and the mid-sternal line. The *semilunar valves of the pulmonary artery* are just behind the junction of the cartilage of the left third rib with the border of the sternum. If the breath is held *upon inspiration*, the interposition of the lungs renders the heart-sounds obscure and uncertain. Fortunately, the structure of the sternum is such that in a measure it serves as a sounding-board, and does not interfere with the transmission of the sounds through a stethoscope.

The difficulty of fixing definitely the points where the sounds of the cardiac valves can be detected by the ear applied to the chest is greatly increased in examining young children, in whom the position of the heart is relatively higher and consequently the sounds of its valves are confused with those of the respiratory organs. In infancy and throughout childhood the heart also is proportionately of greater breadth in comparison with the chest (Plate 42), and the apex-beat will therefore generally be found at a point higher and more external than it is in the adult. The so-called *nipple-line* is not to be relied upon for accurate reference, as the position of the nipple, although usually occupying the fourth intercostal space upon both sides, is subject to variation, as stated in the description of the breast (page 250).

With regard to the physical examination of the chest for the recognition of the condition of the lungs there are several points regarding which the anatomy of the region will offer elucidation. When the hands are held in each other at the back, with the body in the upright position, percussion over the anterior wall of the chest will reveal a clear note wherever the lung-tissue is healthy. By this means an experienced ear and a light touch may enable the physician to map out the area of the

lungs in inspiration (Plate 27) and thus ascertain the degree of their expansion. Over the apices of the lungs at the root of the neck there is a slight resonance, but it is much more clear below the clavicles, where the amount of lung tissue is greater. Generally in this locality there is upon the *right* side normally a comparative degree of dulness, owing to the interposition of the innominate artery and innominate vein. Both sides of the chest should always be percussed symmetrically downward, the area of the heart's dulness being allowed for upon the left side. By this means it will be found that in the *middle* over the sternum during inspiration the resonance is clearest along the upper part of the gladiolus, above the attachment of the cartilages of the fourth ribs. Upon the *right* side the resonance diminishes below the level of the *fifth* rib, as the lung thins out over the liver, until the upper border of the seventh rib is reached, where the absolute dulness of the liver commences. Upon the left side below the sixth rib percussion will gradually elicit the tympanitic note of the stomach.

The posterior lower level lines of the lungs are indicated in the topographical survey of the back, which will be found in Vol. II.

The space included between the reflections of the two pleuræ posteriorly, extending from the roots of the lungs and the pericardium to the sides of the bodies of the dorsal vertebræ, is called the *posterior mediastinum* (page 263). It contains the descending thoracic aorta and its intercostal branches, the œsophagus, the pneumogastric nerves, the thoracic duct, the venæ azygos major and minor, the splanchnic nerves, and some lymphatic glands (Plates 36, 37, 38, and 41, Fig. 2).

The *descending thoracic aorta* commences at the termination of the arch, about the lower border of the body of the fourth dorsal vertebra on the left side, and extends to the twelfth dorsal vertebra. It is closely connected to the spine by a strong investment of the endothoracic fascia, and its course is not straight, as it follows the natural curvature of the spine in this region, and gradually approaches the middle line, where it passes through its proper opening in the diaphragm to become the abdominal aorta. The thoracic aorta is separated from the pericardium by the œsophagus and the pneumogastric nerves (Plates 37 and 38). The root

of the left lung is in front of its upper portion (Plates 39 and 40), which also indents the lung in this relation. As it descends, this portion of the aorta diminishes slightly in calibre (from twenty-three to twenty-one millimetres, or from eleven-twelfths to five-sixths of an inch, in diameter) and gives off at intervals numerous branches. From the anterior surface arise the upper and lower right and left *bronchial arteries*, which accompany the respective bronchi into the lungs, several *pericardiac arteries*, and four or five *œsophageal arteries*, which are distributed to the walls of the pericardium and œsophagus and also to the posterior mediastinal lymphatic glands. From the posterior surface upon each side there are usually *nine* intercostal arteries given off. There are eleven pairs of intercostal arteries, but the upper two are derived from the superior intercostal branch of the subclavian artery (page 229). The right aortic intercostal arteries are longer than the left, owing to the position of the aorta, being for the most part on the left side of the spine, and the upper ones upon each side ascend obliquely to pass along the *intercostal spaces*, while the lower ones pass transversely.

Upon reaching the intercostal spaces, between the side of the vertebra and the superior costo-transverse ligament, each artery divides into an anterior and a posterior branch. The *anterior branch* is the largest, and at first runs along the *middle* of the intercostal space upon the external intercostal muscle, and, in consequence of the internal intercostal muscle being deficient here, is separated from the thoracic cavity only by the endothoracic fascia and costal reflection of the pleura. At the angle of the rib the vessel passes between the two layers of intercostal muscles and becomes lodged in the sub-costal groove of the lower border of the rib above, with its companion vein above and nerve below (Plate 37). Before doing so it sends off a tiny branch called the *collateral intercostal artery*, which runs along the upper border of the rib below. This branch is sometimes large enough to cause troublesome bleeding, and in entering a trocar through any one of the spaces it is better to select the middle of the space, instead of just above the border of the lower rib as generally recommended. The anterior branches of the intercostal arteries anastomose with one another and with the branches from the internal mammary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artery in front (page 257). They distribute blood to the contiguous ribs and muscles, and also by perforating branches to the pectoral muscles, mammary gland, and serratus magnus muscle. The anterior intercostal vessels and nerves pass, as they enter between the intercostal muscles, beneath the chain of sympathetic nerve ganglia (Plates 36 and 37). The *posterior* intercostal arteries pass backward with the dorsal nerves between the transverse processes of the contiguous vertebræ, and divide opposite the intervertebral foramina into the spinal and dorsal branches. The *spinal arteries* enter the spinal canal and immediately subdivide and establish communications with the vessels above and below, so that there are arterial plexuses formed in front and at the back of the cord, called the *anterior* and *posterior neural rete mirabile.* A branch of each spinal artery also pierces the dura mater of the spinal cord, and with similar branches anastomoses upon the anterior and posterior surfaces of the cord itself. The *dorsal arteries* divide into internal and external muscular branches, which supply the various layers of dorsal muscles.

The œsophagus is the continuation of the pharynx, and begins in the neck on a level with the sixth cervical vertebra and the lower border of the cricoid cartilage (Plate 12). It is the narrowest portion of the digestive canal, and leads directly into the stomach, passing in front of the spine to the transverse portion of the arch of the aorta, thence through the posterior mediastinum in front of the descending thoracic aorta (Plate 37) to its proper opening in the diaphragm opposite the ninth dorsal vertebra. It is about twenty-five centimetres, or nine or ten inches, in length. It is most constricted in relation to the fourth dorsal vertebra and at the diaphragm. Its course is somewhat peculiar, being not exactly straight, and, besides conforming to the curvatures of the spine in the different regions through which it passes, it deviates from the middle line in certain localities. At the root of the neck it bulges to the left of the trachea (Plate 36), which, with the lobe of the thyroid body and the left recurrent laryngeal nerve, is situated in front of it. It is separated from the longus colli muscles by the prevertebral expansion of the deep cervical fascia. The left inferior thyroid and common carotid arteries, and the thoracic duct, are close to the left

side of it. Within the thorax the œsophagus passes through the superior mediastinum, extending over a little to the right of the middle line, lying in front of the bodies of the upper dorsal vertebræ. In the posterior mediastinum it is separated from the vertebræ by the thoracic duct, the vena azygos major, and the right upper intercostal arteries. Here it passes forward and to the *left*, and is surrounded below the roots of the lungs by the œsophageal plexus of nerves, which are derived from the right pneumogastric nerve posteriorly and from the left pneumogastric nerve anteriorly. It is in relation with both pleuræ, but more especially the right, and has in front of it the trachea, the left bronchus, the arch of the aorta, and the posterior surface of the pericardium in relation to the left auricle (Plates 38 and 39). The œsophagus terminates at the cardiac orifice of the stomach, about two centimetres, or three-fourths of an inch, to the *left* of the middle line, passing through the diaphragm, and entering the cavity of the abdomen behind the left lateral ligament of the liver and the adjoining peritoneal layers of the lesser omentum.

Upon section the œsophagus appears like a cord with a stellate lumen (Plate 41, Fig. 2, No. 12). It will be observed from the above that the direction of the œsophagus presents two *lateral* curves, one at the root of the neck and the other at the diaphragm, which should not be overlooked in the introduction of a probang or of the stomach-pump. The diameter of the canal varies, being normally at the above-mentioned points of constriction thirteen millimetres, or about half an inch, and in the rest of the passage from seventeen to twenty-one millimetres, or a little over three-quarters of an inch. These measurements are considerably increased by forcible distention: the narrowest portions, however, rarely exceed twenty-two millimetres, or seven-eighths of an inch, in diameter, while the rest of the gullet will stretch to thirty-six millimetres, or one and a half inches. It follows, therefore, that foreign bodies when swallowed are most apt to be arrested at either the upper or the lower portion of the œsophagus.

The operation of *œsophagotomy* for the removal of an impacted foreign body is performed with the patient's neck turned upon the right side over a pillow, so as to render the *left* side prominent where the œsoph-

agus extends to the left of the middle line. The foreign body can usually be felt, and thus serves as a guide. The incision should be free and made parallel to the anterior border of the sterno-mastoid muscle, and the carotid sheath carefully exposed. The latter, together with the trachea, should be drawn forward and the sterno-mastoid muscle outward, every precaution being exercised not to injure the thyroid body, the thyroid vessels, or the recurrent laryngeal nerve, and especially to avoid tearing the surrounding loose cellular tissue, which is very prone to diffuse inflammation.

The distensibility of the œsophagus is due not only to the laxity of its attachments, but also to the character of its coats. These consist of an *external* or *muscular coat*, composed of outer longitudinal and inner circular fibres, which are mostly well developed and pronounced in the upper portion; a *middle* or *areolar coat*, consisting of elastic tissue in which are embedded masses of adenoid tissue and rows of little racemose œsophageal glands (larger below than above), and an *internal* or *mucous coat*, which is continuous with the mucous lining of the pharynx above and with the stomach below, and which when the œsophagus is empty is folded into vertical rugæ. The mucous membrane is quite thick, and is lined with scaly epithelium. The *arteries* to the œsophagus are derived from various sources. In the neck it receives branches from the inferior thyroid artery, within the thorax branches from the descending thoracic aorta, and below the diaphragm a few twigs from the gastric artery. Its veins empty their blood into the gastric, the vena azygos major, and the inferior thyroid veins in their respective localities. The *nerves* are supplied from the œsophageal plexus formed by the pneumogastrics and some filaments from the first dorsal ganglion of the sympathetic nerve.

The *pneumogastric nerves* within the thorax hold different relations upon the two sides. The *right pneumogastric* enters from the neck, between the subclavian artery and subclavian vein, and descends by the side of the trachea to the root of the lung (Plate 39). After giving off the recurrent branches and others which communicate with similar branches from the left pneumogastric nerve and form the posterior pulmonary and œsophageal plexuses, it continues as a single cord along the posterior

wall of the œsophagus to the stomach. The *left pneumogastric nerve*, after entering the thorax from the neck between the left subclavian and carotid arteries and behind the left innominate vein, passes over the arch of the aorta and behind the root of the left lung to the anterior surface of the œsophagus. In its course it gives off branches which combine with those from the right pneumogastric nerve, as already stated, in the formation of the pulmonary and œsophageal plexuses, and continues as a single cord along the anterior wall of the œsophagus to the stomach. The recurrent laryngeal nerves are given off from the pneumogastric nerves within the limits of the superior mediastinum, and have already been particularly described (page 185).

The thoracic duct is the upward continuation of the receptaculum chyli, which receives the converging lacteal vessels from the intestines and the lymphatic vessels from the lower portion of the body, which are described with the region of the abdomen in Vol. II. The duct enters the posterior mediastinum by the aortic opening in the diaphragm, to the right side of the aorta (Plate 37, No. 8, and Plate 38, No. 2), and ascends in a sinuous course in close relation to the right pleural boundary of this space as far as the body of the third dorsal vertebra. Here it passes across to the left side behind the arch of the aorta and the œsophagus, and curves upward to the left side of the latter, between it and the left pleura, to enter the superior mediastinum. Very often the thoracic duct in its upper portion divides into branches, and it usually presents a dilatation where it crosses over the spine. It receives the pleural, intercostal, and left pulmonic lymphatic vessels. When dilated it appears irregular and nodulous, owing to the many pairs of valves with which it is provided. The valves are most numerous in the upper portion, where it ascends between the œsophagus and the left subclavian artery into the neck as high as the seventh cervical vertebra. It then curves downward *over* the subclavian artery, near the anterior border of the scalenus anticus muscle, and empties into the back part of the confluence of the *left* common jugular and subclavian veins (Plate 20, No. 69). At the orifice of the duct there are two well-marked valves, which guard against any regurgitation of the blood from the veins into its canal.

The *vena azygos major* is the great connecting link between the superior and inferior venæ cavæ, making up for their deficiency in the situation of the heart. It commences by tributaries from the right lumbar and renal veins, and often from the inferior vena cava itself, and, passing through the diaphragm at the aortic opening, ascends upon the right side of the spine over the right intercostal arteries to the third dorsal vertebra, whence it arches forward to empty into the superior vena cava as it becomes covered by the pericardium (Plate 37, No. 30). It receives the lower nine or ten right intercostal veins, the spinal veins, and the posterior mediastinal, œsophageal, and right bronchial veins. About the sixth dorsal vertebra the vena azygos major is usually joined by the *vena azygos minor* (Plate 38, No. 13), which ascends up the left side of the spine (Plate 36, No. 84). The latter vein commences in the abdomen by tributaries from the left lumbar veins and the left renal vein, and ascends to the left of the aorta through the left crus of the diaphragm. It receives the lower six or seven of the intercostal veins, besides some of the mediastinal and œsophageal veins. The left upper intercostal veins terminate in a trunk called the *superior vena azygos minor*, which empties into the vena azygos major generally, but sometimes into the inferior vena azygos minor. All the azygos veins are provided with valves, which are not very perfect, however.

The *splanchnic nerves* are the sympathetic nerve cords which are made up of branches from the lower thoracic ganglia, and are distributed to the abdominal plexuses under the names of the greater and lesser splanchnic nerves (Plate 36, Nos. 80 and 83, and Plate 37, Nos. 13 and 15). The sympathetic ganglia in the thoracic region vary in number upon each side from ten to twelve, in consequence of several of them being often united. The *first* is the largest, and they are mostly situated over the heads of the ribs. They are small, grayish-pink, irregular bodies connected by broad, thin, grayish branches, and each ganglion is also connected by a couple of branches, one white and one gray, with the neighboring intercostal nerve. It is thought that these connecting links with the spinal nerves consist of fibres which leave the ganglia at their inner branches and endow them with vaso-motor and viscero-inhibitory functions.

The nerves from the *four upper* ganglia are quite small, and pass inward to join the cardiac and posterior pulmonary plexuses. The nerves from the *six lower* ganglia constitute the greater, the lesser, and the smaller splanchnic nerves. The *great splanchnic nerve* is composed of the most numerous filaments from the fifth, sixth, seventh, eighth, ninth, and tenth ganglia, which combine into a single trunk, and, passing through the crus of the diaphragm on the corresponding side, join the solar, renal, and supra-renal plexuses. The *lesser splanchnic nerve* arises by branches from the tenth and eleventh ganglia, and passes generally to the cœliac plexus; and the *smallest splanchnic nerve* arises as a collateral branch from the twelfth ganglion, and terminates in the renal plexus. The chains of the sympathetic ganglia and their nerve-cords are covered by the reflection of the costal pleura upon each side, which holds them in place, and which must be removed before they can be examined and followed through the diaphragm. The association of the filaments of the splanchnic nerves with the solar plexus probably accounts for many of the obscure symptoms complained of in dyspepsia, which by reflex action manifest themselves in pain in the area of distribution of the cutaneous nerves of the upper part of the back.

THE DIAPHRAGM.

The diaphragm is the thin, movable, arching partition which separates the cavity of the thorax from the cavity of the abdomen. Its construction is very peculiar, as it consists of muscular and tendinous portions which arise by numerous digitations and, arching upward and inward, converge to be inserted into a common *central tendon*. To the upper surface of the central tendon are attached the fibrous pericardium and the dense lateral bands which are prolonged from the deep cervical fascia, already described (page 259). These serve to maintain the arch of the diaphragm and to keep the central tendon in position while the muscular portions are in constant motion during respiration (page 273). When looked at from *below*, the whole diaphragm resembles somewhat a large palm-leaf, while the central tendon appears almost a counterpart in form: hence the differ-

ent portions of each, in front and at the sides, are called the *leaflets*. Of these the right leaflet is the largest. In structure the central tendon consists of intersecting fibres which pass in all directions and then radiate among the muscular fasciculi, thus affording additional strength. It is of a glistening bluish-white color. The *muscular portion* of the diaphragm arises by fleshy digitations from the ensiform cartilage, from the inner surfaces of the six lower ribs on each side, interdigitating with the attachment of the transversales abdominis muscles, and from the *tendinous arches* over the quadratus lumborum and psoas muscles on each side, which consist of condensations of the extra-peritoneal fascia in this locality, and are known, from their ligamentous nature, respectively as the *ligamentum arcuatum externum* and the *ligamentum arcuatum internum* (Plate 63, Nos. 6 and 31, Vol. II.). The ligamentum arcuatum externum extends from the twelfth rib to the transverse process of the first lumbar vertebra, and the ligamentum arcuatum internum extends from the transverse process of the first lumbar vertebra to the body of the second. Lower down upon the lumbar vertebræ are two variably-developed and always unsymmetrical fleshy portions, called the *crura of the diaphragm*, because their component fibres in passing upward cross each other in such a way that they usually form a figure-of-eight arrangement around the openings for the aorta and the œsophagus (Plates 62 and 63, Vol. II.).

The *aortic opening* is in the middle line in front of the spine between the two crura, and gives passage to the descending aorta, with the thoracic duct and the vena azygos major on its right side. The *œsophageal opening* is in the muscular portion above and in front of the aortic opening, and transmits, besides the œsophagus, the right and left pneumogastric nerves (page 317). To the right of the latter, and in the highest part of the central tendon, is the *opening for the inferior vena cava*, which also gives passage upward to some of the hepatic lymphatic vessels, and occasionally to a branch of the right phrenic nerve. The wall of the inferior vena cava is adherent to the central tendon where it passes through it, so that it is not subjected to pressure in the action of the adjacent muscular leaflet. Besides these three great openings there are several smaller ones under the crura, which allow the splanchnic nerves to enter the abdomen from the

thorax (page 320). On the left side the vena azygos minor gains entrance to the thorax (page 319). On each side of the ensiform cartilage there is a triangular space which gives passage to the epigastric branch of the internal mammary artery, and to the lymphatic vessels from the anterior wall of the abdomen into the anterior mediastinum (page 259). Occasionally this becomes distended by an abscess or by a diaphragmatic hernia. The diaphragm receives branches from the lower intercostal and internal mammary arteries, but is mainly supplied with blood by the two phrenic arteries, which arise from the aorta just as it issues through its proper opening.

The *nerves* of the diaphragm are the phrenic (page 207) and some of the branches of the lower five or six intercostal nerves, which are reinforced by sympathetic fibres from the neighboring supra-renal plexuses. These fibres form the diaphragmatic plexuses, and on the right side there is a little ganglion (*diaphragmaticum*), from which filaments pass to the liver. The diaphragm, next to the heart, is the most extraordinary muscular arrangement in the body. Its upper surface arches into the thoracic cavity, on each side, at *variable heights* (Plate 40), reaching during *expiration* about the level of the fifth rib on the right side and of the sixth rib on the left (page 265), and during *inspiration* sinking about an inch, and thus pushing downward the abdominal viscera to a slight degree. It is through the alternate contraction and relaxation of its muscular portions that it enters largely into the mechanism of respiration, aiding, in this important process, the expulsion of the air from the lungs, by acting in harmony with the rest of the thoracic walls and thus accommodating the cavity of the thorax to the degree of expansion of these elastic organs. It is concerned in coughing, sneezing, and laughing, as is manifest by its rapid contractions during those acts. It also assists the abdominal muscles in compressing the viscera in vomiting and defecation, and in the efforts of parturition. The under surface of the diaphragm is covered by the peritoneum, as described with the region of the abdomen in Vol. II.

THE UPPER EXTREMITY.

The region of the shoulder is formed by the clavicle, the scapula, and the upper part of the humerus (Plate 28), together with the structures surrounding them, by which the upper extremity is attached to the thorax. The *skin* over this region is comparatively thin, and although there may be a considerable amount of fat in the subcutaneous tissue in certain localities, which softens and subdues the surface markings, yet the prominences of the bony framework can always be detected by the sense of touch. The clavicle, the acromion process, and the spine of the scapula are readily felt through the skin. In order to determine with accuracy these landmarks it is advisable to refer to the corresponding points of the opposite shoulder, and to take advantage of the extreme mobility of the parts, for by rotation, abduction, and adduction many factors otherwise obscure will be explained. The clavicle and the scapula are the framework of the shoulder proper, and with those of the opposite side form the *shoulder girdle.* This girdle is incomplete posteriorly, owing to the gap between the two scapulæ, which are connected with the thorax solely by muscles, while in front the two clavicles are supported upon and connected with the top of the sternum. The shoulder girdle is remarkable for its lightness and great mobility.

The clavicle, or collar bone, is the long irregular bone which extends from the sternum outward over the first rib to the summit of the shoulder, which it forms with the acromion process of the scapula (Plate 28). In the upright position the clavicle usually inclines a little upward at its outer end, and in the recumbent position this is increased in consequence of the weight of the limb being removed. It is subject to variable physical proportions, much depending upon the amount of strain and effort required of the muscles which are attached to it. In the female it is usually smoother and more slender than in the male. The right clavicle is often shorter than the left. The bone presents a peculiar sigmoid curvature, so that the anterior border begins by curving forward at the sternal end, and at

the middle gradually curves backward to the acromial end, where it juts outward. The posterior border is exactly the reverse. The degree of curvature of the inner portion of the clavicle is very variable, especially in men, the freedom and much of the grace of movement of the upper extremity depending upon it. The *sternal end* is a prominent, rough, thick, triangular-shaped process covered with a dense fibrous tissue. It is provided with an irregular facet, which at its lower part rests upon the shallow facet on the upper border of the sternum, and with the interposition of a disk of fibro-cartilage establishes the important *sterno-clavicular joint.* This joint is provided with two pouches of synovial membrane, one above and the other below the interarticular cartilage, enclosed within a capsular ligament, of which there are two strong bands of fibres, one stretching in front of and the other behind the surfaces of the contiguous bones. They are called respectively the *anterior* and *posterior sterno-clavicular ligaments.* These bands are reinforced by the *interclavicular ligament,* which is in reality a differentiation of the deep cervical fascia extending between the ends of the two clavicles across the top of the sternum, and the *costo-clavicular* or *rhomboid ligament,* which ascends inward from the cartilage of the first rib to the costal tuberosity of the clavicle. This is now regarded as a differentiation of the sheath of the subclavius muscle. It is remarkably strong, and limits the elevation of the clavicle. Although the sterno-clavicular joint is the only direct connection between the upper extremity and the thorax, it is very rarely dislocated. It has been demonstrated that the peculiar sloping arrangement of the articular facets of this joint allows the sternum to advance slightly upon the end of the clavicle in inspiration (Morris). The acromial end is rough, broad, and flattened, and presents upon its under surface an obliquely-directed oval facet for articulation with the acromial process of the scapula, forming the *claviculo-acromial joint.* This joint is provided with superior and inferior ligaments, the superior being much the stronger, and a reflected synovial membrane. There is sometimes a rudimentary fibro-cartilage within. It is capable of very slight gliding motion, but, slight as this motion is, it is essential to the perfect freedom and harmonious movement of the upper extremity. This joint is liable to rheu-

matic inflammation, and the resulting rigidity will cause weakness in certain movements of the limb. Very often the outer end of the clavicle appears to be tilted above the acromion process, instead of occupying the same level. This is probably due to partial separation of the connecting ligaments from some severe strain. It is not attended with any impairment of function. The inner two-thirds of the shaft of the clavicle are rounded, and its posterior concave surface arches over the subclavian vein and artery and the cords of the brachial plexus of nerves (Plates 30 and 31).

The upper surface of the bone is smooth and subcutaneous, being readily recognizable through the skin, which is always thin and loosely attached over it. The anterior and posterior borders of the upper surface are roughened to a variable extent toward each end. The anterior border gives attachment to the pectoralis major muscle at its inner half, and to the deltoid muscle at its outer. The posterior border receives the insertion of the clavicular portion of the sterno-mastoid muscle (page 197) inwardly, and of the trapezius muscle outwardly (Plate 16). The under surface presents at the sternal end a small facet for the reception of the first rib, which is in reality a portion of the sternal articular surface. Close to the outer side of this is the rough costal tuberosity for the attachment of the rhomboid ligament, beyond which along the middle of the shaft is the *subclavian impression* for the subclavius muscle. The costo-coracoid membrane (page 255) is attached to the ridge in front of this impression and a reflection of the deep cervical fascia from the omo-hyoid muscle to a ridge behind it. Sometimes there is a rough line in the middle of the impression, in which case it affords insertion to a fibrous septum in the subclavius muscle.

Upon the under surface of the shaft, where it spreads out to form the acromion, there is at its posterior border an eminence called the *conoid tubercle*, from which an *oblique line* extends to the outer end of the anterior border. The conoid tubercle is directly over the coracoid process of the scapula, to which it is connected by the *conoid ligament*. The oblique line gives attachment to the *trapezoid ligament*, which arises from the coracoid process, the two ligaments being practically portions of one, the

PLATE 45.

Figure 1.

Dissection of the right axillary space and inner side of the arm to show the relation of the vessels and nerves.

1. The anterior ulnar vein.
2. The posterior ulnar vein and branches of the internal cutaneous nerve.
3. The median basilic vein.
4. The basilic vein.
5. The lesser internal cutaneous nerve.
6. The greater internal cutaneous nerve.
7. The triceps muscle.
8. The ulnar nerve.
9. The brachial vein.
10. The superior profunda artery and veins.
11. The intercosto-humeral nerve.
12. The latissimus dorsi muscle.
13. The dorsalis scapulæ artery.
14. The sub-scapular artery and veins.
15. The second sub-scapular nerve.
16. The third sub-scapular nerve.
17. The axillary glands embedded in adipose tissue.
18. The long thoracic artery.
19. The serratus magnus muscle.
20. The posterior thoracic nerve, or external respiratory nerve of Bell.
21. The median vein.
22. The median cephalic vein.
23. The cephalic vein.
24. The biceps muscle.
25. The median nerve.
26. The brachial artery.
27. The coraco-brachialis muscle.
28. The deltoid muscle.
29. The cephalic vein.
30. The sternal portion of the pectoralis major muscle.
31. The right clavicle.
32. The severed trapezius muscle.

Figure 2.

Deep dissection of the right axilla and inner side of the arm. The deltoid and pectoralis major and minor muscles are detached and reflected to show the intricate relations of the brachial plexus of nerves to the artery and veins.

1. The fascia of the forearm and branches of the internal cutaneous nerves.
2. The median basilic vein.
3. The median nerve covering the brachial artery.
4. The anastomotica magna artery.
5. The lesser internal cutaneous nerve.
6. The greater internal cutaneous nerve.
7. The ulnar nerve.
8. The superior profunda artery.
9. The inferior profunda artery.
10. The triceps muscle.
11. The ulnar nerve, passing beneath the basilic vein.
12. The latissimus dorsi muscle.
13. Connecting venous link between the basilic and brachial veins.
14. The basilic vein before it empties into the axillary vein.
15. The axillary glands.
16. The intercosto-humeral nerve.
17. The sub-scapular artery and veins.
18. The sub-scapular nerves.
19. The blending of the veins of the forearm over the tendon of the biceps muscle.
20. The cephalic vein.
21. The biceps muscle.
22. The basilic vein.
23. The brachial artery.
24. The brachial vein.
25. The median nerve.
26. The coracoid attachment of the biceps muscle.
27. The musculo-cutaneous nerve.
28. The thoracico-humeral artery.
29. The coraco-brachialis muscle.
30. The coracoid attachment of the severed pectoralis minor muscle.
31. The inner cord of the brachial plexus of nerves.
32. The axillary artery.
33. The main brachial vein before its entrance into the axillary vein.
34. The brachial plexus of nerves.
35. The acromio-thoracic artery.
36. The severed pectoralis major muscle, reflected.
37. The serratus magnus muscle.
38. The posterior thoracic nerve.
39. The short thoracic artery.
40. The great axillary vein.
41. The right clavicle.
42. The trapezius muscle.

Fig 1

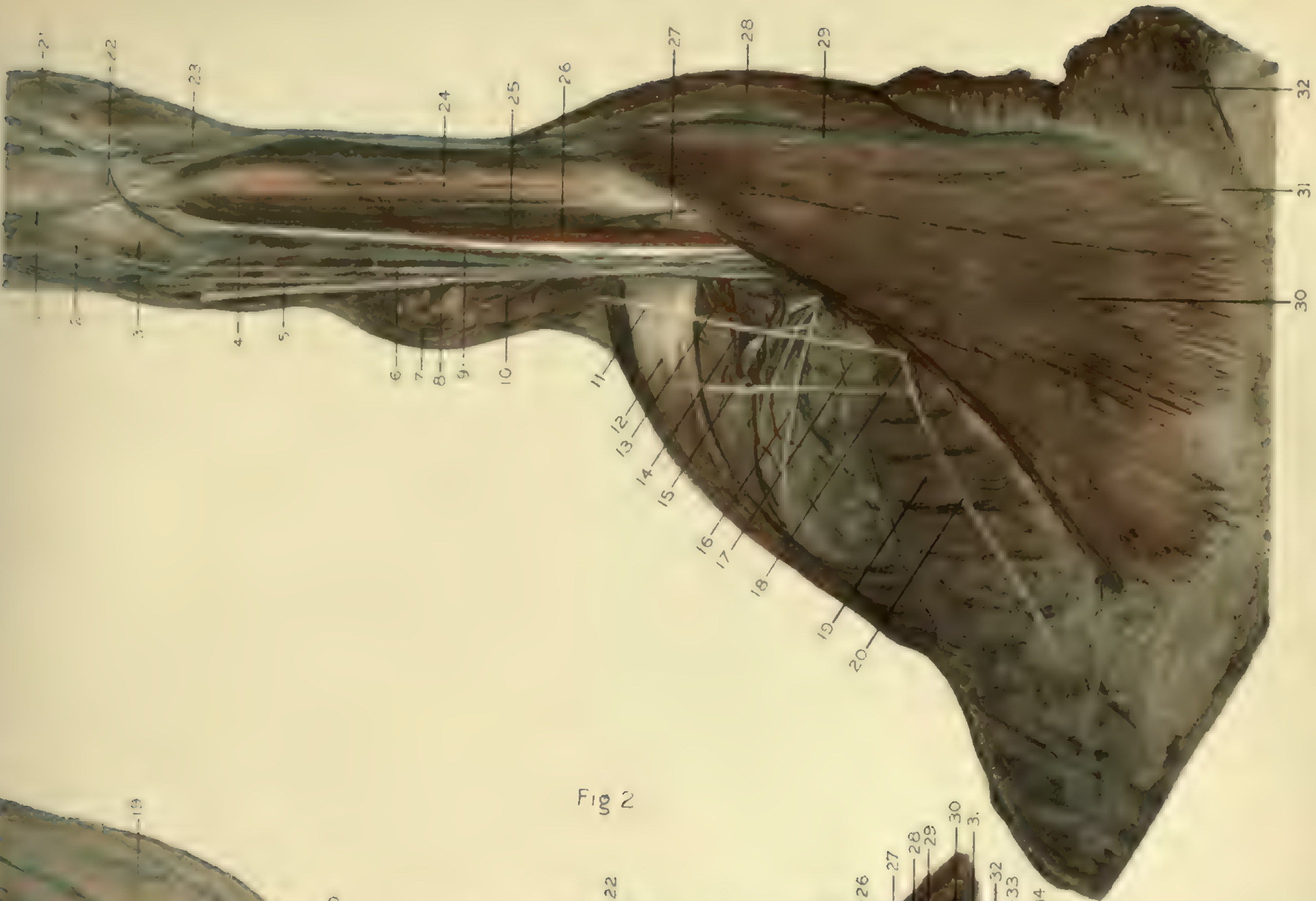
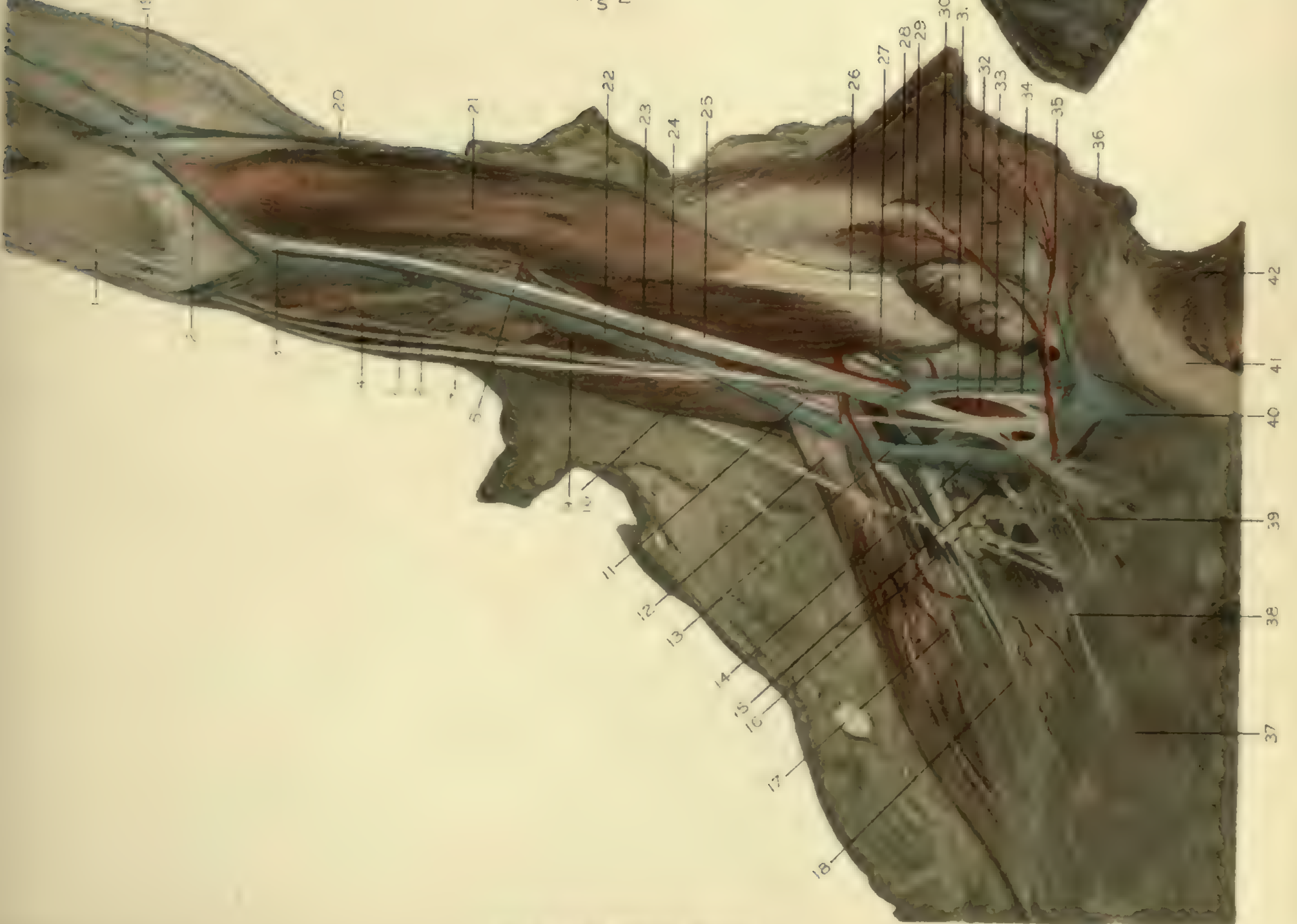


Fig 2



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coraco-clavicular ligament. They severally serve to restrain the movements of the shoulder. The curved formation of the clavicle renders it sufficiently elastic to compensate for its otherwise weak construction, so that it is capable of moderating the effects of ordinary concussions received through the shoulder. Its outer surfaces consist of compact tissue, which is much thicker at the middle of the bone, and the interior consists of large-meshed spaces of cancellous tissue containing reddish-colored marrow usually at the sternal end.

The clavicle is peculiar not only in that it is the first bone of the skeleton to ossify, but also in that ossification begins in its primary fibrous substance before the deposition of cartilage. At birth the entire shaft is bony, although the ends are cartilaginous. The sternal end is the sole epiphysis to the clavicle, and it is joined to the shaft about the twenty-fifth year. It is rarely separated from the shaft by accident, owing to the close ligamentous attachments of the sterno-clavicular joint, but the powerful pectoralis major muscle might produce displacement in a young person. This bone is frequently the seat of *green-stick fracture,* owing to the exceedingly thick and loose periosteum which surrounds it in childhood, as well as to its more early ossification. *Fractures of the clavicle* occur frequently at all ages, in consequence of the manner of its construction and its exposed position, and they are generally occasioned by indirect violence. The commonest form of fracture occurs at the outer end of the middle third of the bone, the resistance against concussion being weakened by the junction of the two curves of the bone at this point. The direction of the fracture is *oblique,* and whatever degree of displacement may occur is chiefly through the agency of the weight of the upper extremity upon the *outer* fragment, the *inner* fragment rarely changing its position. The outer fragment may also be drawn inward and somewhat rotated, so that it projects in advance of the inner, by the contraction of the muscles attached to the upper portion of the humerus and the coracoid process of the scapula. The great obstacle to the complete reduction of such a fracture is the inability to maintain the scapula in position, owing to the gliding movements which are caused by its suspension in a sling of muscles at the side of the thorax. All the ingenuity which has been

expended in devising apparatus to restrain the scapula has thus far failed, and consequently has been unsuccessful in overcoming the shortening of the bone in the process of repair. Union, however, usually occurs with marvellous rapidity (in from twelve to fourteen days), even when no dressing has been used, and with little impairment of function.

The **scapula**, or shoulder-blade, is a flattish, triangular bone, situated at the back of the upper part of the thorax, and, in the properly articulated skeleton, extending between the second and seventh ribs. It consists mainly of a broad thin plate, the *body*, with raised and roughened *borders*. Its *dorsal surface* is smooth and slightly convex, and is divided near its upper third by a prominent projection of bone, the *spine*, into two hollows, called the *superior* and *inferior spinous fossæ*. The supra-spinous fossa lodges the *supra-spinatus muscle*, the fibres of which arise from its inner portion and from the dense fascia with which it is invested and converge to a strong tendon, which glides over the outer part of the fossa and across the capsular ligament of the shoulder-joint to be inserted into the *superior* facet on the greater tuberosity of the humerus. The infra-spinous fossa presents several faint ridges toward the vertebral border, from which and their interspaces the fibres of the *infra-spinatus muscle* arise, and blend to form a tendon which passes over the upper part of the axillary border, from which it is sometimes separated by a bursa, and across the capsular ligament of the shoulder-joint, to be inserted into the *middle* facet on the greater tuberosity of the humerus. This muscle is also firmly bound down by an enveloping fascia. The *teres minor muscle* arises from the upper two-thirds of the axillary border by fibres which pass obliquely upward and form a narrow elongated mass, which mostly terminates in a tendon to be inserted into the *inferior* facet on the greater tuberosity of the humerus, and by a few muscular fibres into the humerus immediately below. The tendon of this muscle also passes across the capsular ligament of the shoulder-joint. The teres minor muscle is separated from the contiguous muscles by fibrous laminæ, which also give origin to some of its component fibres. About the centre of the attachment of the teres minor there is a groove in the axillary border, which accommodates the dorsalis scapulæ vessels. The *teres major muscle* arises by fibres attached to the lower part of the axillary

border, being separated by an oblique line from the preceding muscle, and by fibres extending over the inferior angle of the scapula. They form a broad mass which ascends outwardly, and, deviating from the teres minor, from which it is separated by the middle portion of the triceps muscle, is inserted by a flat tendon, about five centimetres, or two inches, in length, into the *internal* ridge of the bicipital groove of the humerus. The lower border of this tendon blends with the lower border of the *latissimus dorsi muscle*, forming the posterior boundary of the axillary space (page 338), and is inserted conjointly with it. The upper portion, however, is inserted independently, having a synovial bursa interposed between it and the proper attachment of the latissimus dorsi, which is at the bottom of the upper part of the bicipital groove. The latter muscle as it passes from its origin in the back (Vol. II.) crosses over the inferior angle of the scapula, to which it is usually attached by a fibrous expansion, so that it serves to retain this portion of the scapula in place. Occasionally there is no connection between the latissimus dorsi muscles and the two scapulæ, they being separated by synovial bursæ. In such a condition the scapulæ are apt to jut out like wings beneath the skin of the back.

The vertebral border between the inferior angle and the root of the spine receives the attachment of the *rhomboideus muscle.* This muscle is sometimes divided by a septum into two portions. The upper portion is then called the *rhomboideus minor*, in distinction from the lower portion, or *rhomboideus major.* The fibres of the latter are inserted chiefly into a *tendinous arch* extending from the inferior angle half-way up the vertebral border. The rhomboideus muscle consists of a flat mass of strongly-developed fibres which arise from the spinous processes of the vertebra prominens and the five upper dorsal vertebræ. Its action is to antagonize the serratus magnus muscle, by drawing the scapula upward and backward. It receives a branch from the fifth cervical nerve, which also supplies the muscle immediately above, the *levator anguli scapulæ*, which arises from the neck (page 208) and is attached to the scapula between the superior angle and the root of the spine. The smooth triangular surface over the root of the spine has in the recent state a mucous bursa, or a layer of loose connective tissue, over which the trapezius muscle plays

as it passes to its insertion along the upper margin of the spine, as previously described (page 208). The spine gradually projects from the dorsal surface, arising out of the smooth triangle at the vertebral border until it ends in the flattened, rough, quadrilateral *acromion process*, which is twisted so that it overhangs the shoulder-joint.

The superior border of the scapula extends outwardly from the superior angle and ends in the curiously crooked projection called the *coracoid process*, at the root of which there is usually a *notch*, the *supra-scapular*, for the passage of the supra-scapular nerve, the companion vessels passing immediately over it. This notch is often a distinct foramen, or is converted into one, like similar notches elsewhere, by the presence of a transverse ligament. To this ligament, or to the inner border of the supra-scapular notch, is attached the scapular end of the omo-hyoid muscle.

The *coracoid process* is very much like the little finger half bent, and extends forward over the shoulder-joint, where it can be felt during life below the clavicle. The inner border receives the attachment of the pectoralis minor muscle (page 255), and from its point the coraco-brachialis and short head of the biceps muscles arise by a common tendon. The coracoid and acromion processes have a strong fibrous band extending between them, called the *coraco-acromial ligament*, which forms an arch over the shoulder-joint and prevents the head of the humerus from being dislocated upward.

The anterior or thoracic surface of the body of the scapula is concave, presenting a broad sub-scapular fossa, or *venter*, with three or four slight ridges at the vertebral border, which give origin to the intersections between the bundles of fibres of the *sub-scapularis muscle*, which completely occupies the fossa. Toward the root of the coracoid process this surface of the bone is smooth and the tendon of the sub-scapularis muscle passes over it, there being a large bursa interposed across the capsule of the shoulder-joint to be inserted into the *lesser* tuberosity on the anterior part of the top of the humerus. The fibres from the axillary border of the fossa are inserted into the neck of the humerus two and a half centimetres, or about an inch, below the tuberosity. The chief action of this muscle is to rotate the head of the humerus *inward*. The whole of the anterior

surface of the vertebral border of the scapula receives the insertion of the *serratus magnus muscle.* This flat muscle forms the inner wall of the axilla (Plate 44, Fig. 1, and Plate 45, Fig. 2). It arises by nine digitations from the upper eight ribs (there being two attached to the *second* rib), which are arranged according to the direction of the fibres into superior, middle, and inferior portions. The *superior* is formed by the junction of the slip from the first rib with the anterior slip from the second rib by a small tendinous arch, and is inserted into the border of the superior angle of the scapula. The *middle* is made up of the posterior slip from the second rib with slips from the third and fourth ribs, and is inserted into the vertebral border and the neighboring fibrous arch. The *inferior* is the strongest part, consisting of slips from the fifth, sixth, seventh, and eighth ribs, and is inserted into the anterior surface of the inferior angle of the scapula. This muscle is covered by the contents of the axilla (Plate 45) and the skin over the side of the chest, and is supplied by the posterior thoracic nerve (page 345). Its function is to draw forward the scapula round the chest wall, but when the scapula is fixed its action is reversed, so that it becomes a powerful *inspiratory* muscle. At the external margin of the spine on the dorsal surface beneath the acromion process there is a notch by which the supra-spinatus and infra-spinatus fossæ communicate: this is called the *great scapular notch.* Through this notch the supra-scapular artery passes and establishes the important anastomosis with the dorsalis scapulæ and posterior scapular arteries (page 342).

The anterior angle is the thickest part of the bone, and is called the *head,* while the constricted portion posterior to it is the *neck.* The head presents an oval shallow fossa, the *glenoid cavity,* which is narrower above than it is below, and is directed vertically outward, forward, and a little upward, for the reception of the head of the humerus. At the upper edge is the *supra-glenoid tubercle,* for the attachment of the long tendon of the biceps muscle, and at the lower edge is the rough *infra-glenoid tubercle,* for the origin of the middle or long head of the triceps muscle. This fossa is deepened in the recent state by the *glenoid ligament,* which consists of a prismatic fibro-cartilaginous band continuous with the expansion of the

fibres of attachment of the above-mentioned muscles round the margins. The central portion of the body of the scapula is extremely light, sometimes being deficient in ossific matter, and the periosteum surrounding the bone is strong and laminated, and especially developed upon the various processes and borders.

The upper end of the humerus consists of a smooth *hemispherical head*, directed upward, inward, and backward, to be received against the glenoid cavity of the scapula. The constriction about the head is known as the *anatomical neck.* From this the *greater tuberosity* extends outward. It is a rough prominence, presenting three facets, an upper, a middle, and a lower, for the attachments of the supra-spinatus, infra-spinatus, and teres minor muscles, as already described. From the anterior part of the anatomical neck the *lesser tuberosity* projects directly forward, the tendon of the sub-scapularis muscle being inserted into it. Between these tuberosities there is a deep vertical furrow, the *bicipital groove,* for the accommodation of the long tendon of the biceps muscle (Plate 44, Fig. 2). Below the tuberosities, as far as the middle of the shaft, the bone is cylindrical, and is known as the *surgical neck,* in consequence of the frequency with which it is fractured.

The shoulder-joint consists of the adaptation of the smooth surface of the head of the humerus upon the glenoid cavity of the scapula, thereby constituting an *enarthrodial* or *ball-and-socket joint.* These bony surfaces are each covered with articular cartilage in such a manner that it is thickest at the margins of the glenoid cavity and thinnest at the centre, while upon the head of the humerus the reverse is the case, the cartilage being thicker at the centre and thinner toward the anatomical neck. The *capsular ligament* is attached above to the circumference of the glenoid cavity and below to the anatomical neck, except at its inner and lower part, where it extends some little distance below. It is in itself a quite weak structure, being composed of a very loose layer of fibrous tissue. It is thickest at its upper part, where it is strengthened by the V-shaped *coraco-humeral ligament,* and serves mainly as an outer layer for the synovial membrane, offering very little security to the joint, which in reality depends upon the great strength and number of the tendons of

the muscles with which it is intimately associated. When these tendons are completely severed, the head of the humerus will fall away from the glenoid cavity to the extent of two and a half centimetres, or an inch, or even more, so loose is the capsular ligament; and likewise the arm appears to be lengthened when the muscles which ordinarily support it are paralyzed. In fact, the capsule is large enough to accommodate the head of the femur, which is nearly twice the size of the head of the humerus. A knowledge of the arrangement of the tendons about the joint is therefore of great importance, not only in realizing the wide range of motion of which the joint is capable, but also in understanding how to readjust it in case of its dislocation.

The tendons of the supra-spinatus, infra-spinatus, and teres minor muscles, as they pass over the capsule to their respective insertions upon the greater tuberosity, strengthen the upper and posterior part; the broad tendon of the sub-scapularis muscle protects it on the inner part, where it comes forward to be inserted into the lesser tuberosity; and below it receives support from the long head of the triceps muscle. Furthermore, the *long tendon of the biceps muscle*, which is lodged within the deep groove between the tuberosities, pierces the capsular ligament and passes over the head of the humerus to the top of the glenoid cavity, strengthens the upper anterior part of the joint, and prevents the head of the humerus from being brought against the acromion process in the upward movements of the arm. In fact, it is mainly by the normal position of this tendon, assisted somewhat by the atmospheric pressure, that the head of the humerus is retained in its natural position. Occasionally the biceps tendon is dislocated out of its groove onto the inner ridge, and abduction is limited by the great tuberosity thus coming almost immediately in contact with the acromion process. From a careful consideration of the disposition of the tendons it will be seen that they surround the capsule, except toward the axilla, where the head of the humerus can be readily felt. When the arm is raised and extended, the head of the humerus rests upon the weak part of the capsule; and it is therefore through this part, between the tendons of the sub-scapularis and the long head of the triceps, that most of the dislocations at this

joint occur. If the capsule is opened, it presents upon its interior several folds, which have been specialized as *gleno-humeral folds.* The synovial membrane is reflected upon the inner surface of the capsule and forms fringes at the borders of these folds, and is invaginated about the biceps tendon, which it follows as a tubular sheath down the groove to the extent of five centimetres, or two inches. There is a constant small opening at the upper and inner side of the capsule, which admits the tendon of the sub-scapularis muscle, and by which the synovial membrane communicates directly with the bursa under the tendon. There is also often an opening from the capsule leading into the bursa beneath the tendon of the infra-spinatus muscle. In chronic disease of the joint sinuses are readily established in the sites of the bursal connections. There is no anatomical communication between the capsule and the bursa under the deltoid muscle, which is interesting because the *sub-deltoid bursa* is peculiarly liable to independent disease. It is contained within an expansion of loose connective tissue beneath the deltoid and overlying the tendons of the spinati muscles. The shoulder-joint is practically a universal joint, and, as it depends upon the arrangement and power of the surrounding tendons, rather than upon the mechanical adjustment of the opposing bony surfaces, the grouping of the muscles in effecting the various movements should be understood. *Extension* is effected by the teres major, latissimus dorsi, and the posterior portion of the deltoid. These are assisted in raising the arm by the teres minor and infra-spinatus muscles. *Flexion* is produced by the coraco-brachialis and the anterior portion of the deltoid, aided by the pectoralis major; *abduction*, by the deltoid and supra-spinatus; *adduction*, by the pectoralis major, teres major, latissimus dorsi, and coraco-brachialis.

The shoulder is rotated *outward* by the infra-spinatus and teres minor, and *inward* by the sub-scapularis, latissimus dorsi, and teres major. The shoulder-joint is supplied by the circumflex nerve and circumflex artery, which are described on page 342. The deep structures of the shoulder-joint are protected by the great *deltoid muscle,* which forms a complete shoulder-cap. It arises from the lower border of the outer third of the clavicle, from the acromion process, and from nearly the whole of the spine

of the scapula (Plate 16). This extensive origin corresponds to that of the trapezius muscle above (page 208). The muscular fibres composing the deltoid are very coarse, and are disposed in bundles or fascicles which are separated by inward expansions of the strong layer of the deep fascia enveloping the muscle upon its outer surface. The bundles thus formed by the fibres arising from the clavicle and from the spine of the scapula generally converge from their origins to their insertions upon the lateral ridges of the deltoid tuberosity, but those of the outer or acromial portion are peculiarly arranged. Here there are additional fibres which originate from the sides of the intramuscular tendinous septa in a bipenniform manner and pass parallel to one another to be inserted by fleshy slips into the middle ridge of the deltoid tuberosity on the outer surface of the shaft of the humerus. The *deltoid tuberosity* consists, therefore, of three converging ridges. The tendon of insertion can be understood only by detaching the muscle from its origin and reflecting it. When this is done, it will be seen that the insertion is about three and three-quarter centimetres, or an inch and a half, in length, extending upward upon the middle of the shaft from the *deltoid ridges*, whence fibrous septa are projected into the substance of the muscle between the fibres originating from the aponeurotic expansions between the fasciculi. In this manner the several fasciculi reinforce one another, and the increased number of their fibres compensates for their length, thus greatly augmenting the functional power of the muscle as a whole. Looked at from in front, the insertion of the deltoid resembles the letter V. It is embraced by the fleshy origins of the brachialis anticus muscle, and thus occasions a characteristic depression of the overlying integument. The three parts of the muscle can act separately in raising the arm in different directions, and they each act to better advantage when the humerus is rotated outwardly. The power of the deltoid depends greatly upon the scapula being steadied by the serratus magnus, the long head of the triceps, and the middle fibres of the trapezius muscles. When the whole muscle contracts, it raises the arm to the horizontal position (at an angle of ninety degrees): beyond this it cannot act, further elevation being effected by the serratus magnus and trapezius, which then raise the shoulder. The deltoid muscle receives its

blood from the circumflex arteries (page 342), and is supplied by the circumflex nerve (page 346).

When the head of the humerus is dislocated into the axilla, the rotundity of the shoulder is lost, the deltoid becomes flattened, and the acromion process is rendered very prominent. In such a condition there is beneath the latter process a marked depression, into which one or two fingers can be inserted, constituting one of the diagnostic features of dislocation at the shoulder-joint. Dislocation at this joint is very common. Primarily the displacement is always downward into the axilla, because it is caused by direct violence received upon the point of the shoulder or by indirect violence while the upper extremity is abducted and the joint consequently placed at a disadvantage, the head of the humerus readily slipping through the lowest and weakest part of the capsule (page 332). Sometimes the head of the bone is retained in this position, when it is called a *sub-glenoid* dislocation. After leaving the capsule, however, the pectoralis major and other muscles having free play, it is most frequently drawn forward and inward, and assumes the character of a *sub-coracoid* dislocation. Rarely the head of the humerus is driven backward under the acromion upon the dorsum of the scapula (*sub-spinous* dislocation). In every form of dislocation there will be flattening of the deltoid and more or less stretching of that muscle, and consequently abduction of the arm, with proportionate rigidity. The chief diagnostic symptoms are as follows: the elbow stands away from the side of the body, and the hand of the affected limb cannot be placed in the small of the back nor upon the top of the opposite shoulder. There have been many observations regarding the special anatomy of the various forms of dislocation at the shoulder, but they are of no practical use, beyond the inference that the head of the humerus, in order to be returned to its proper place, must be *first* restored to the sub-glenoid position, and *then*, by circumduction or other means, its reduction may be accomplished. The proximity of the important structures within the axilla renders them liable to injury from pressure of the head of the humerus when it is driven against them, and that they escape with so little damage is probably due to the relaxation of the soft parts which follows upon the shortening of the limb.

Fractures involving the *anatomical neck* of the humerus are extremely rare, and can only be *suspected*, unless an opportunity is given to explore the joint. The prolongation of the internal and lower fibres of the capsular ligament would connect the fragments unless they were also ruptured. The *superior epiphyseal line* is below the tuberosities, just where the shaft is widest. It does not become obliterated before the twenty-second year. The upper epiphysis may become detached prior to this period, and simulates the condition of a fracture in the upper part of the surgical neck of the humerus without overlapping.

In *amputation at the shoulder-joint* it is essential that the incisions should be made so as to leave the division of the axillary vessels to the last moment. Whatever method is employed, the long tendon of the biceps muscle should be sought for, and by using its bony furrow as a *grooved director* the capsule can be slit up and the joint expeditiously opened. In the *oval flap method,* which the author has found to possess many advantages, the relations of the severed vessels and nerves as they present themselves in the flaps after amputation at the left shoulder are as follows (Plate 50, Fig. 2). The *anterior flap* is formed by the pectoralis major (No. 3), the heads of the biceps, coraco-brachialis, latissimus dorsi, teres major, and rotator muscles. The axillary vessels (Nos. 1 and 2), the cords of the brachial plexus of nerves (No. 11), and the inferior scapular artery and veins (No. 12) will be found in the axillary border of this flap; while the long tendon of the biceps (No. 5), a branch of the anterior circumflex artery (No. 7), and the cephalic vein and the descending branch of the acromio-thoracic artery (No. 8) occupy the acromial border of the flap in relation to the severed clavicular portion of the deltoid muscle. The *posterior flap* is formed mainly by the scapular portions of the deltoid muscle (No. 15), with branches of the posterior circumflex vessels and nerves (No. 14).

THE REGION OF THE AXILLA.

The region of the axilla, or armpit (Plates 44 and 45), varies in depth with the position of the arm. It is a pyramidal space, bounded internally by the side of the thorax, externally by the arm, and in front

and behind by prominent muscular folds. The *anterior fold* is formed by the lower border of the pectoralis major muscle (page 253), while the *posterior fold* is formed by the lower borders of the latissimus dorsi and teres major muscles (page 329). The *skin* of the axilla is closely connected with the subjacent superficial fascia, is provided with long hairs which radiate toward the borders of the cavity, and contains numerous sebaceous glands of a reddish-brown color, which are liable to become inflamed and produce superficial abscesses. It also has very large sweat-glands, and a dense net-work of lymphatic vessels in the corium. There is more or less fat in the meshes of the subcutaneous tissue. The deep fascia is called the *axillary fascia*. It is very dense, and bears important relations to the fasciæ of the regions of the neck, thorax, and shoulder. It consists of a close fibrous layer stretching across the base of the axilla, between the anterior and posterior folds. It is continuous with the deep fascia surrounding the pectoralis major muscle (page 255), and with the *costo-coracoid membrane* above, which, since it draws up the axillary fascia toward the clavicle, is known sometimes as the *suspensory ligament of the axilla*. It produces the characteristic "hollow" of this region. The space beneath the axillary fascia is mainly occupied by a quantity of very loose connective tissue and fat, in which pus or extravasated blood often collects to an extraordinary amount, being checked in its progress toward the surface by the fascia. In consequence of the barrier which this fascia also presents laterally, there is a tendency for unrelieved abscess in this region to extend into the neck along the sheath of the vessels in the direction of least resistance. In opening an axillary abscess, a small incision should first be made through the deep fascia of the floor of the space, upon the *inner* side, midway between the two axillary folds. As soon as the pus is reached, the opening can safely be enlarged upon a grooved director. Trifling as this operation may seem to the uninitiated, it is fraught with danger unless due precaution is taken to avoid the important structures on the outer and upper part of the space. The muscles forming the posterior wall of the axilla are the latissimus dorsi, teres major, and sub-scapularis. The anterior wall is formed by the under surfaces of the pectoralis major and minor muscles. Upon the inner wall

are the four upper ribs, with their intercostal muscles, covered by the serratus magnus. The biceps and coraco-brachialis are upon the outer wall, between the convergence of the two axillary folds. At the apex of the space the axillary vessels and nerves descend outwardly from the root of the neck, whence they bring with them a funnel-shaped prolongation of the deep cervical fascia. This communication between the neck and the axilla constitutes the *cervico-axillary passage.* It is bounded by the first rib, the clavicle, and the upper border of the scapula. In order to see the contents of the axilla, the axillary fascia must be removed. Within the layers of this fascia a small artery will sometimes be found, probably arising from the brachial artery, crossing the floor of the space quite superficially. It is noteworthy, as it is directly in the way of the usual incision for opening an axillary abscess. Whenever the knife is used in this region, great caution must be exercised, and after the preliminary incision it is better to resort to the handle of the knife or to the finger to separate the loose connective tissue and thus expose the lymphatic glands, vessels, and nerves, the relations of which deserve particular attention. Not far from the surface the *posterior lateral cutaneous branches of the intercostal nerves* will be found perforating the chest wall between the digitations of the serratus magnus muscle (Plate 45). Of these the posterior lateral branch of the second intercostal nerve is specialized as the *intercosto-humeral nerve*, because it supplies the skin of the inside of the arm as low as the internal condyle (Plate 27, No. 41). It passes across the upper part of the axilla, issuing from the second intercostal space. There is also an intercosto-humeral nerve from the third nerve, which receives a branch from the second and accompanies it in its distribution. The anterior branches of the above two nerves supply the skin upon the side of the chest and on the axillary folds.

The axillary artery is the continuation of the subclavian, and commences at the lower border of the first rib, whence it passes downward and outward along the coraco-brachialis muscle to the lower border of the posterior fold of the axilla. It is separated from the inner side of the shoulder-joint by the insertion of the sub-scapularis muscle into the lesser tuberosity of the humerus. The pectoralis minor muscle (page 255)

PLATE 46.

Figure 1.

The anterior view of the right elbow and forearm of an adult male, with the superficial fascia carefully removed to show the relations of the superficial veins and nerves.

1. The median nerve in the lower third of the arm, overlapping the brachial artery.
2. The brachial artery.
3. The biceps muscle.
4. The external brachial vein.
5. The external (in this case independent) cephalic vein.
6. The median cephalic vein.
7. The musculo-spiral nerve.
8. The fascia from the biceps tendon, passing beneath the superficial veins at the head of the elbow.
9. A branch of the musculo-cutaneous nerve.
10. A branch of the recurrent radial artery.
11. The median veins (in this case double).
12. The radial vein.
13. The radial nerve.
14. The radial artery with its venæ comites.
15. The tendon of the supinator longus muscle.
16. The median nerve, above the wrist.
17. The ulnar nerve.
18. The triceps muscle.
19. The greater internal cutaneous nerve.
20. The lesser internal cutaneous nerve.
21. The internal brachial vein.
22. The anastomotica magna artery.
23. The basilic vein.
24. Branches of the ulnar nerve.
25. Branches of the internal cutaneous nerve.
26. The anastomosing vein.
27. Deep fascia over the flexor muscles.
28. The ulnar vein.
29. The flexor carpi radialis muscle.
30. Branches of the musculo-spiral nerve.
31. Carpal branch of the internal cutaneous nerve.
32. The ulnar nerve.
33. The tendon of the flexor carpi ulnaris muscle.
34. The flexor sublimis digitorum muscle.
35. The ulnar artery and its venæ comites.
36. The external carpal branch of the ulnar artery.
37. The annular ligament.

Figure 2.

Deeper dissection of same arm as Figure 1. The bicipital fascia and the superficial flexor muscles are removed, while most of the superficial veins are retained to preserve their relations.

1. The brachial artery.
2. The biceps muscle.
3. The median nerve.
4. The external brachial vein.
5. The external cephalic vein.
6. The median cephalic vein.
7. The tendon of the biceps muscle.
8. The brachial artery, surrounded by the brachial veins.
9. The musculo-spiral nerve.
10. The communication between the superficial and deep veins, by the vena anastomotica.
11. The anterior interosseous branch of the median nerve.
12. The supinator longus muscle.
13. The median vein.
14. The anterior interosseous artery, with its venæ comites.
15. The radial artery, with its venæ comites.
16. The shaft of the radius.
17. The radial nerve.
18. Carpal branch from the radial artery.
19. The triceps muscle.
20. The internal cutaneous nerve.
21. The ulnar nerve.
22. The basilic vein.
23. The internal brachial vein.
24. Branches of the ulnar nerve, over the internal condyle.
25. The cut attachment of the superficial flexor muscles.
26. The deeper portion of the pronator radii teres muscle.
27. The bifurcation of the brachial artery.
28. The origin of the interosseous artery.
29. A muscular branch from the ulnar artery.
30. The ulnar nerve.
31. The flexor carpi ulnaris muscle.
32. The median nerve.
33. The ulnar artery, with its venæ comites.
34. The pronator quadratus muscle.
35. Carpal branch of the ulnar artery.

Fig 1

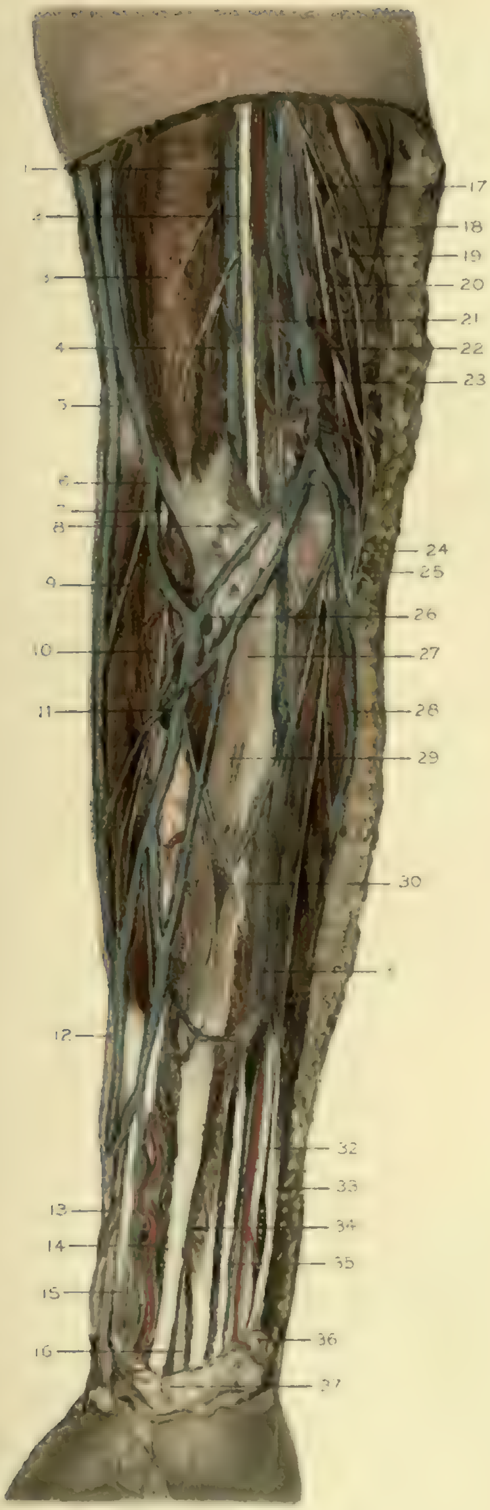
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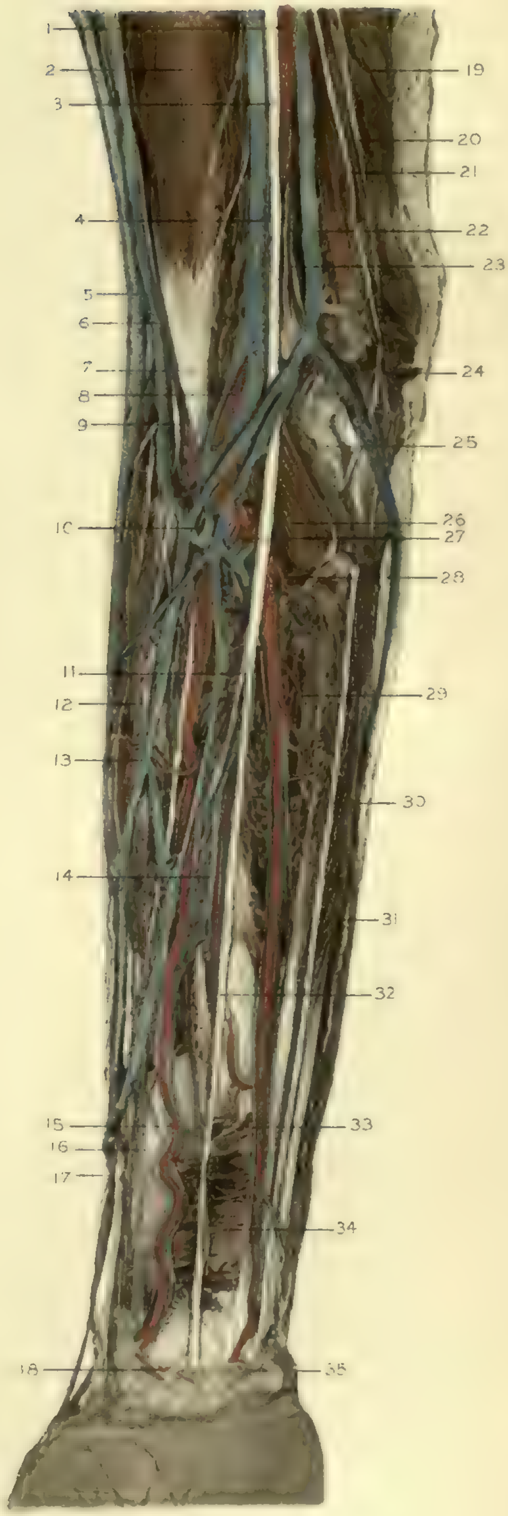
Fig 2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passes across the middle of the artery to be inserted into the coracoid process, so that the vessel is usually described according to its position,—above, under, or below that muscle. In its course there are many branches from it distributed to the neighboring regions. Above the pectoralis minor the superior thoracic and acromio-thoracic arteries arise independently or by a common axis. The *superior thoracic* passes along the border of the pectoralis minor, and, descending between it and the pectoralis major, supplies them both and anastomoses with branches from the intercostal and internal mammary arteries. The *acromio-thoracic* artery usually divides very near its origin, as it pierces the costo-coracoid membrane, into several branches. They are the small *thoracic* or pectoral, to the serratus magnus and pectoralis minor muscles, the *descending* or *thoracica humeraria* (Holden), which descends in close relation to the cephalic vein between the deltoid and pectoralis major muscles, both of which it supplies, and the *acromial* and *clavicular* branches. The *acromial* crosses the coracoid process to the under surface of the deltoid muscle, and establishes a communication (the *rete acromiale*) with the posterior circumflex and supra-scapular arteries. The *clavicular* supplies the subclavius muscle. The companion veins of these arteries terminate either in the cephalic or in the axillary vein,—generally in the latter.

The *alar thoracic* artery arises variably from the axillary trunk or from its long thoracic branch. It supplies the anterior lymphatic glands embedded in the connective tissue of the axillary space. The *long thoracic artery* (Plate 44, Fig. 1, No. 7) descends close to the lower border of the pectoralis minor muscle. It sometimes gives off the alar artery, but its *external mammary branch* is usually quite large in the female and passes to the breast along the lower border of the pectoralis major. The *short* and *long sub-scapular arteries* are variable in their origin. The *short sub-scapular* is distributed mainly to the under surface of the sub-scapular muscle. The *long sub-scapular artery* is the largest of all the branches of the axillary. It descends in relation to the sub-scapularis muscle and divides into anterior and posterior branches. The anterior or thoracic branch descends in relation to the posterior fold of the axilla to the side of the chest, where it ends in the serratus magnus. It also sends a small

twig to the inferior angle of the scapula which anastomoses with branches from the dorsalis scapulæ and posterior scapular arteries. The posterior branch of the long sub-scapular artery is called the *dorsalis scapulæ* (Plate 45, Fig. 2, No. 17). It passes into the *sub-scapular triangle*, which is formed by the long head of the triceps muscle passing between the sub-scapularis and teres major muscles to its insertion at the inferior border of the glenoid cavity (page 354). Here it gives off a deep branch which breaks up into smaller branches in relation to the ridges of the sub-scapular fossa. The *superior* of these branches is important, because it supplies an articular artery to the shoulder-joint and the principal nutrient artery to the venter of the scapula. The main trunk of the dorsalis scapulæ artery winds round and grooves the axillary border of the scapula under the centre of the attachment of the teres minor muscle. Here it supplies this muscle and the adjoining infra-spinatus muscle, and anastomoses with branches from the *posterior circumflex* and *posterior scapular* arteries. The *veins* which accompany these arteries terminate in the sub-scapular veins, which empty into the axillary veins.

Owing to the many sources of arterial supply to the scapula and its muscles and their free anastomoses, the removal of the scapula, or even of growths involving a portion of it, is attended with profuse hemorrhage. All the main vessels above described require a ligature in these operations, and consequently their *relative* positions should be carefully studied.

The *posterior circumflex artery* is nearly as large in diameter as the sub-scapular. It arises opposite to it, and sometimes with it by a common trunk, and passes backward, accompanied by its two veins and the posterior circumflex nerve, round the posterior surface of the neck of the humerus, to the under surface of the deltoid muscle. This artery establishes communications with the branches from the acromio-thoracic and supra-scapular and the ascending branch from the superior profunda, and supplies not only the neighboring muscles, but also the head of the humerus and the shoulder-joint. The *anterior circumflex artery* is much smaller than the posterior, and passes under the coraco-brachialis and the coracoid head of the biceps close to the anterior surface of the neck of the bone. In relation

to the bicipital groove this vessel gives off the little *bicipital artery,* which accompanies the long head of the biceps to the capsule of the shoulder-joint and to the head of the humerus. It enters the capsule by a foramen at the top of the bicipital groove. The anterior circumflex communicates with the posterior circumflex beneath the deltoid muscle.

There is great variability in the position of the branches of the axillary artery, and sometimes, although rarely, it furnishes the radial or the ulnar artery to the forearm.

When the arm is extended in the supine position, a line drawn from the middle of the clavicle to the point where the anterior axillary fold crosses the inner border of the biceps muscle corresponds to the course of the axillary artery. This line also indicates the position of the *intermuscular cleft* between the sternal and clavicular portions of the pectoralis major muscle, in which the axillary artery can be most easily reached, as it lies upon the first intercostal space below the clavicle. The point where the pectoralis minor muscle crosses the artery may be designated by a line drawn from the coracoid process to the junction of the third rib and its cartilage. The artery is inaccessible for a ligature beneath the pectoralis minor muscle, so that its relations above and below that muscle are of peculiar interest to the surgeon. When tied in the upper part, the collateral circulation is established through the same vessels as after the ligature of the outer part of the subclavian artery (page 232). In the operation for tying the lower part of the axillary artery the incision should be made upon the inside of the bulge of the biceps muscle when the arm is extended, and by following upward along the border of the coraco-brachialis muscle the artery will be found enveloped in its sheath and closely surrounded by the two brachial veins, the basilic vein, and the median and ulnar nerves. In this relation there are often connecting links between the veins extending across the artery, and often, too, accessory slips from the latissimus dorsi muscle to the insertion of the pectoralis major, and therefore, in spite of the artery being more superficial in this locality, it is very difficult of access. The collateral circulation here is similar to that which occurs upon the ligation of the brachial artery above the origin of the superior profunda,—*i.e.,* by the communication of that vessel with

the branches of the posterior circumflex and the neighboring muscular arteries. If, before applying the ligature, the forearm is flexed and the position of the arm is changed, there can be little difficulty in distinguishing between the artery and the nerve-cord of the brachial plexus, which is close to it. This nerve-cord has been mistaken for the artery in several recorded instances.

The axillary vein is the continuation of the basilic vein upward from the lower border of the posterior axillary fold to the outer border of the first rib. In its course it receives as tributaries the venæ comites of the branches of the axillary artery, except the circumflex veins, which either join the sub-scapular or empty into one of the brachial veins. Either just before or at its termination in the subclavian vein the axillary vein receives the two brachial veins and the cephalic vein (Plate 45, Fig. 2). The orifices of the tributary veins are guarded by single valves, but there are double valves at the termination of the main trunk. The axillary vein is more superficial than the artery, and throughout most of its course, when the arm is at the side, the vein is in front of and internal to the artery, but when the arm is slightly raised the vein, although still in front, is below the artery. If the arm is raised to more than a right angle, the vein will *overlap* the artery above the pectoralis minor. Just above its commencement the axillary vein is separated from the artery by some of the nerves of the brachial plexus. The costo-coracoid membrane is intimately adherent to the external coat of the axillary vein where it pierces that dense fascia to empty its blood into the subclavian vein. This attachment serves to keep the vessel open when it is wounded, and probably explains the great rush of blood when it is severed. Its position also renders it liable to be influenced by the inspiratory movements of the chest, and thus air may be drawn into the heart through the vessel if the latter be wounded. In amputation at the shoulder-joint (Plate 50, Fig. 2) it is important to secure the axillary vein with a ligature immediately after tying the axillary artery.

The brachial or axillary plexus of nerves is formed by the anterior branches of the fifth, sixth, seventh, and eighth cervical and first dorsal nerves, each branch consisting of muscular and cutaneous fila-

ments in close association. The fifth receives a descending or communicating branch from the fourth cervical above it, and then joins with the sixth to form the *upper trunk* of the plexus. The seventh cervical pursues an independent course as far as the clavicle, and is the *middle trunk*, while the eighth cervical and first dorsal as they issue from beneath the scalenus anticus muscle unite in relation to the first rib to form the *lower trunk* (Plate 4, Fig. 2, and Plates 20, 25, and 33). The arrangement of the nerves contributing to the plexus is variable, especially upon the left side, but the following corresponds to most of the author's dissections. At the outer border of the scalenus medius muscle the three great nerve-trunks divide into anterior and posterior branches. The anterior divisions from the upper and middle trunks form the *outer cord of the plexus*, the anterior division from the lower trunk furnishes the *inner cord*, and the posterior divisions of the upper and middle trunks unite behind the axillary artery to form the *posterior cord*, which also receives the small posterior division of the lower trunk, but the latter is often found passing directly to form part of the musculo-spiral nerve. At its commencement the plexus is broad (Plate 25), but it becomes narrow opposite the clavicle (Plate 36), and forms below it an intricate interlacement about the axillary artery (Plate 45, Fig. 2) beneath the pectoralis minor muscle. In the root of the neck the nerve-trunks receive some filaments from the cervical ganglia of the sympathetic nerve, and the fifth cervical nerve sends a branch to join the phrenic nerve as it passes down over the scalenus anticus muscle (page 221). The *branches* from the brachial plexus *above the clavicle*, besides the one to the phrenic nerve, are *small muscular nerves* to the longus colli and scalene muscles, and a branch which pierces the scalenus medius and accompanies the posterior scapular artery to supply the levator anguli scapulæ and rhomboid muscles. The *supra-scapular nerve* arises from the upper trunk of the plexus, and passes to the superior border of the scapula *beneath* the suprascapular artery through the notch in the scapula. It furnishes nerves to the spinati muscles and to the shoulder-joint. The *posterior thoracic nerve* (or external respiratory nerve of Bell) arises usually from the upper trunk, at the outer border of the scalenus medius, and sometimes receives a branch

from the middle trunk. It passes behind the axillary artery, and supplies the serratus magnus muscle, which it enters upon the outer surface (Plate 45, Fig. 2, No. 38).

The *branches below the clavicle* are mainly for the supply of the arm. The *external* and *internal anterior thoracic nerves* arise by filaments from the anterior divisions of the three trunks of the plexus. The *external anterior thoracic nerve* pierces the costo-coracoid membrane in close relation with the acromio-thoracic artery, and supplies the adjacent parts of the pectoralis major muscle. The *internal anterior thoracic nerve* is joined by a filament from the former, and, after passing between the axillary vessels, supplies the pectoral muscles. The *sub-scapular nerves,* three in number, arise from the posterior cord of the plexus and are distributed to the subscapularis, teres major, and latissimus dorsi muscles. The nerve to the last muscle is called the *long sub-scapular nerve,* and accompanies the subscapular artery to the lower border of the muscle. The *circumflex nerve* arises from the posterior cord anterior to the sub-scapular nerves. It is a large nerve, and after sending a filament to the shoulder-joint it accompanies the posterior circumflex artery round the surgical neck of the humerus beneath the deltoid muscle. It divides into many branches, which supply the skin over the deltoid and the upper and back part of the arm (Plate 27, No. 37). Very curiously, the branch of the circumflex nerve which supplies the teres minor muscle possesses a small pseudo-ganglion close to its origin. Branches also pass to the front and back parts of the capsular ligament. The terminal branches of the brachial plexus are described with the arm (page 357).

The lymphatic glands of the axilla (Plates 44 and 45) receive the lymphatic vessels from the upper extremity, from the back, from the anterior portion of the chest, and from the *outer* portion of the mammary gland (page 251). They form a continuous chain with the cervical lymphatic glands passing beneath the clavicle to the root of the neck. They are about a dozen in number, of variable size, and are mostly in close relation to the axillary vein and its larger tributaries. There is also a cluster of the glands situated more superficially than the deeper ones, and embedded in the loose connective tissue and fat of the axillary space. The

thoracic and sub-scapular arteries furnish blood to the deeper glands, while the superficial ones are supplied by the alar thoracic artery. The lymphatic vessels from the outer side of the arm and shoulder pass to a couple of glands in the groove between the deltoid and pectoralis major muscles, over the costo-coracoid membrane, near the cephalic vein. The efferent vessels from these usually pass to the cervical glands directly, while the lymphatic vessels from the inner side of the arm terminate in three glands situated along the axillary vein. A gland is generally found in relation to the sub-scapular artery, and another on the tendon of the latissimus dorsi close to the humerus. The superficial lymphatic vessels of the back are derived from the whole expanse of that region, from the nape of the neck to the loins. They converge to the axilla, and end in the glands in the upper and back part of the cavity.

The lymphatic vessels from the nipple, the areola, and the outer portion of the breast convey their lymph to two or three glands situated upon the serratus magnus muscle under cover of the lower border of the pectoralis major muscle. The efferent vessels from all the axillary glands resolve themselves into four lymph-trunks, which pass along with the subclavian vein and terminate upon the right side in the right lymphatic duct and upon the left side in the thoracic duct (page 318). When the axillary glands are in a normal condition they cannot be felt through the skin; and it is not always possible to detect them even when they are slightly enlarged. Their secondary involvement in scirrhous disease of the breast is so common that it is advisable in all such cases, when an operation is resorted to, to extend the incision into the axillary space, so that the finger can thoroughly explore the cavity. With the exception of the removal of the chain of cervical glands from about the internal jugular vein, there is no operation of a similar nature more trying to the skill and patience of the surgeon than the removal of the axillary glands about the axillary vessels. They are closely associated at all times with the thin walls of the great veins in this region, but when implicated with disease their relation is of the most intimate character, and they have literally to be peeled off one by one, at imminent risk of rupturing the veins. No rough handling of the structures in the apex of the axilla

during an operation would be countenanced by one whose scalpel had ever unravelled the intricacies of these parts in his student days.

THE REGION OF THE ARM.

The arm extends from the axilla to the elbow. It has already been stated (page 332) that the shape of the shaft of the humerus above the deltoid insertion is cylindrical; below it is prismatic and slopes gradually downward and slightly forward to the lower end, where it becomes transversely flattened (Plate 28). The central portion of the lower end of the humerus is peculiarly formed for articulation with the ulna. It is called the *trochlea*, and consists of a smooth, rounded, condyloid surface, which is constricted at the middle so that the inner portion is somewhat larger and projects lower than the outer. Above the constriction anteriorly there is a depression for the reception of the coronoid process of the ulna when the forearm is flexed, called the *coronoid fossa.* Posteriorly there is a similar but larger depression, the *olecranon fossa,* for the olecranon process of the ulna when the forearm is extended. The portion of bone between these fossæ is exceedingly thin and translucent, and sometimes perforated, forming the *supra-trochlear foramen.* Jutting out from the internal portion of the trochlear surface is a prominent process, the *internal epicondyle,* and to the periosteum over this process the flexor muscles of the wrist and hand are attached. The internal epicondyle looks directly inward when the arm hangs naturally at the side, and occupies a lower plane than the *external epicondyle,* which is the corresponding process upon the outer portion of the trochlear surface. The latter is rough and comparatively short, and gives attachment to the origins of some of the extensor muscles. Upon the outer surface of the trochlea is a small spheroidal forward projection, called the *capitulum,* upon which the cup-shaped depression on the head of the radius rests and glides within the elbow-joint. The outer and inner borders are directly continuous with the epicondyles, and are known as the *external* and *internal supra-condyloid ridges.* Upon the posterior surface of the *internal* epicondyle there is a slight *groove for the ulnar nerve.* The epicondyles are the only parts of the humerus which are subcuta-

neous, and, although the shaft of the humerus can be felt through the soft structures, there are no other bony prominences, and therefore the *surface-marking*, which is due to the contour of the various muscles, is of particular interest in relation to the subjacent parts. This is more pronounced in well-developed muscular men than among women whose arms are rounded and of regular outline. Fat, here, as in other parts of the body, always subdues the depressions and renders them less discernible.

The *skin* on the front and inner surface of the arm is especially smooth, free from hairs, delicate, and extremely sensitive, while on the back and outer surface it is somewhat thicker and less sensitive. The skin is also loosely attached to the deeper parts by the *subcutaneous fascia*. This is often manifest in cellulitis, and in amputation through this part of the upper extremity the laxity of the integument allows it to be drawn away from the muscles with very little effort. For this reason the method of applying the knife *from without inward* in amputation through the arm is suggested to those who may be called upon to do this operation without much practical experience, as it secures *flaps with bevelled edges* (Plate 51, Fig. 1).

The triangular depression caused by the insertion of the deltoid muscle (page 335) can generally be recognized upon the surface with ease, and, as it indicates the precise mid-point of the shaft of the humerus, it is an important landmark. Exactly opposite to it, upon the inside of the arm, is the insertion of the coraco-brachialis muscle. The bulge of the biceps muscle causes its outline to be usually well defined in the front of the arm, so that there are furrows or depressions upon each side of it. The *outer bicipital depression* extends from the bend of the elbow to the insertion of the deltoid, and corresponds to the position thus far of the *cephalic vein* (Plate 45, Fig. 1, No. 29), which ascends above this in the groove between the deltoid and pectoralis major muscles and empties into the axillary vein. It is accompanied by the descending branch of the acromio-thoracic artery and the upper external cutaneous nerve. Sometimes there is a connecting vein between the cephalic vein and the external jugular or the subclavian, which passes over the clavicle, and, being subcutaneous, is readily seen during life. The *inner bicipital depression* is more notice-

PLATE 47.

Figure 1.

The radial border of the forearm and elbow, showing the relations of the superficial veins—the superficial fascia being carefully removed—to the muscles and tendons.

1. The biceps muscle.
2. The external cephalic vein, a direct continuation of the radial vein.
3. Branches of the musculo-cutaneous nerve.
4. The musculo-spiral nerve.
5. The tendon of the extensor communis digitorum muscle.
6. The tendon of the extensor secundi internodii pollicis muscle.
7. The posterior annular ligament.
8. The external brachial vein.
9. The median nerve.
10. The basilic vein.
11. The bicipital fascia.
12. The median vein.
13. Branches of the musculo-spiral nerve.
14. The tendon of the flexor carpi radialis muscle.
15. The tendon of the supinator longus muscle.
16. The radial nerve passing round to the back of the wrist.
17. The tendon of the extensor ossis metacarpi pollicis muscle.
18. The tendon of the extensor primi internodii pollicis muscle.
19. The radial artery, seen through the deep carpal fascia.

Figure 2.

The anterior view of the left elbow to show particularly the bicipital fascia in relation to the superficial veins and the deep vessels and nerves.

1. The brachial artery.
2. The basilic vein.
3. The anastomotica magna artery.
4. The ulnar nerves.
5. The internal cutaneous nerve.
6. The branches of the ulnar and internal cutaneous nerves around the internal condyle of the humerus.
7. The ulnar vein.
8. The branches of the internal cutaneous nerve in the forearm.
9. The biceps muscle.
10. The median nerve.
11. The brachial vein.
12. The median basilic vein.
13. The brachial artery at the bend of the elbow.
14. The tendon of the biceps muscle.
15. The median cephalic vein.
16. The vena anastomotica.
17. The bicipital fascia.
18. The median vein.

Figure 3.

Dissection of the veins on the back of the hand and forearm, with their relations to the underlying tendons and nerves.

1. The posterior ulnar vein.
2. The common ulnar vein.
3. The posterior annular ligament.
4. The carpal branch of the ulnar nerve.
5. The *vena salvatella.*
6. The posterior radial vein.
7. The radial vein.
8. The radial nerve.
9. The radial artery.
10. One of the dorsal interossei arteries.

Fig 1

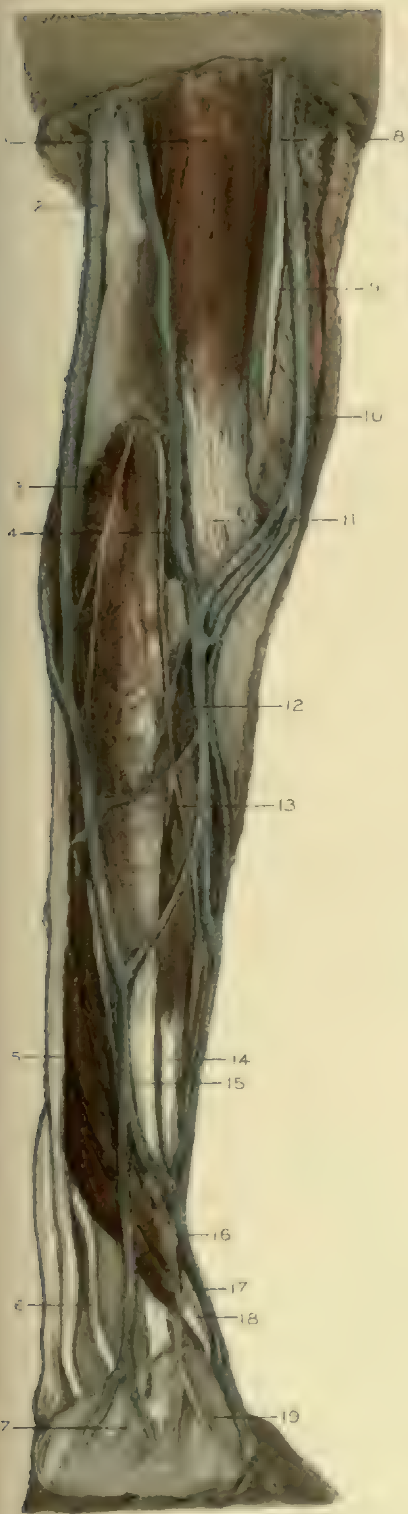

Fig 2

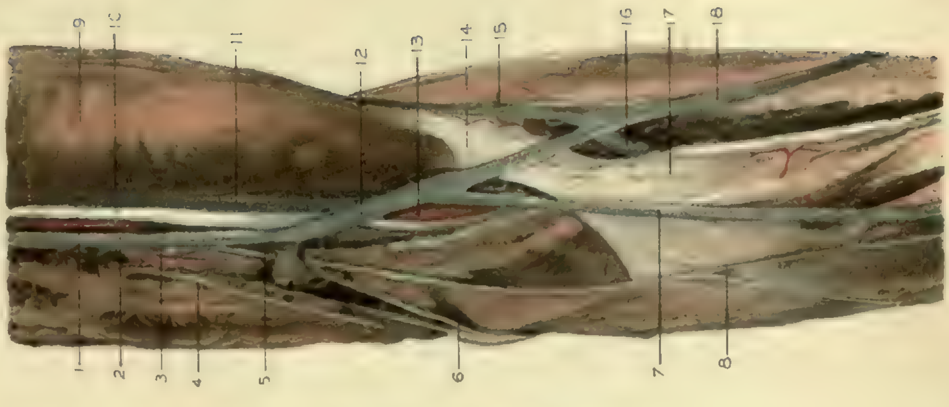

Fig 3

able than the outer; it extends from the middle of the bend of the elbow all the way to the axilla, and indicates the course of the brachial artery and its companion veins and nerves.

The *deep fascia of the arm* is a continuation from the fascia of the shoulder and axilla. It forms a close-fitting investment for all the muscles in this region, and sends into each condyloid ridge of the humerus strong septa which divide the muscles in front from those behind. In certain localities it expands so as to form protected passage-ways for important vessels and nerves, as over the *musculo-spiral groove* on the posterior surface of the humerus for the nerve of that name and the superior profunda artery which accompanies it, and on the border of the humerus above the internal condyle, where it sometimes forms a dense band across the median nerve. Here its attachment to the humerus is occasionally ossified, presenting a hook-shaped process of bone, which is then called the *supra-condyloid process.* The deep fascia is also pierced here and there by the nerves which pass down to be distributed to the forearm, and at the middle of the internal bicipital depression there is an oval opening, the *hiatus semilunaris,* for the basilic vein.

There is marked variability in the density of the deep fascia in its different relations. Thus, over the biceps it is quite thin, but upon the inside of the arm, where it passes between the biceps and the brachialis anticus, it is very strong, forming a dense sheath for the brachial vessels and nerves and binding them upon the surface of the latter muscle. At the back of the arm the fascia constitutes a strong envelope over the biceps muscle, and in front, as it approaches the elbow in relation to the tendon of the biceps, it is also remarkably strong.

The *biceps muscle* is so called because it has a double origin. The *long head* arises by a long round tendon from the top of the glenoid cavity and the glenoid ligament, and, arching over the head of the humerus within the capsule of the shoulder-joint, pierces the latter between the two tuberosities and descends in the bicipital groove between them, covered with a reflection of the synovial membrane of the joint (page 334), which serves to lubricate it and facilitate its movements. It is held in place by the tendon of the pectoralis major muscle, which passes over it to be

inserted into the outer ridge of the groove, being also connected to the latter muscle by its sheath. The *short head* arises by fleshy and tendinous fibres from the point of the coracoid process together with the coraco-brachialis muscle (Plate 44, Fig. 2, No. 23). About the middle of the arm the two heads unite and form a single mass of muscle, which is subject to great variation in development in different individuals, and terminates suddenly in a strong flat tendon. This tendon is of considerable length, is subcutaneous, and can be readily felt upon contraction of the muscle. It *twists* somewhat upon itself and sinks into the ante-cubital fossa to be inserted into the lower and posterior part of the bicipital tubercle of the radius, a bursa being interposed between the tendon and the front of the tubercle. Before the tendon enters the fossa it gives off from its inner border a *semilunar fold of fascia* which protects the brachial vessels and the median nerve at the bend of the elbow (Plates 46 and 47).

The *action* of the biceps muscle is to both *flex* and *supinate* the forearm. The function of supination ensues upon the manner of its insertion into the *posterior* part of the tubercle of the radius, and is most effectually accomplished when the elbow is bent, because the tendon then passes at a right angle to its insertion. The peculiar *ligamentous* function of the long tendon at the shoulder-joint has already been described (page 333). The biceps receives two branches from the brachial artery. One of these is called the *vas aberrans* (page 355). It enters about the middle of the muscle, and divides within its substance into ascending and descending branches. Each head of the muscle receives a branch from the musculocutaneous nerve (page 362).

The *coraco-brachialis* (Plate 44, Fig. 2, No. 7, and Plate 45, Fig. 2, No. 29) is a slender muscle on the inner side of the short head of the biceps, in common with which it arises by fleshy fibres from the coracoid process of the scapula. It is inserted by a flat tendon at the middle of the inner surface of the shaft of the humerus, just above the foramen for the nutrient artery to that bone. This muscle is pierced by the musculocutaneous nerve in its upper portion (Plate 45, Fig. 2, No. 27), which also supplies it. Its action is to draw the arm forward and inward upon the

side of the chest. Not only is the upper portion of this muscle the guide to the axillary artery (page 343), but, as the brachial artery is in relation to its *flat* tendon of insertion, it can here be effectually compressed if the pressure is directed outward. This is the usual site for the application of a tourniquet; but it should always be remembered that the close relation of the median nerve (page 357) renders it liable to be included in the pressure and therefore to cause great pain. There is a bursa interposed between the tendons of the coraco-brachialis and the short head of the biceps and the tendon of the subscapularis muscle over the head of the humerus.

The *brachialis anticus muscle* arises by two fleshy portions, one upon each side of the insertion of the deltoid, and from the lower part of the front surface of the humerus, which it covers. Its inner border is also connected with the septum from the deep fascia which separates it from the triceps posteriorly. Its fibres are arranged in nearly parallel bundles, so that they form a broad thick mass superposed upon the capsule of the elbow-joint, to which it is slightly attached. Its tendon is flat, and upon the outer border extends into the substance of the muscle. It is chiefly inserted into the coronoid process of the ulna, and reflected upon a ridge from this process to the tuberosity of the ulna. It forms a pad to the elbow, upon which the brachial vessels and the median and musculo-cutaneous nerves are supported internally, as they pass across the joint under protection of the expansion from the tendon of the biceps muscle. Externally the brachialis anticus is quite superficial, and separated from the supinator longus muscle by a furrow in which is lodged the musculo-spiral nerve (Plate 47, Fig. 1, No. 4), from which it receives a small branch, although its main nerve-supply is from the musculo-cutaneous nerve upon its inner side. Its *action* is to flex the elbow.

The *triceps extensor cubiti* is so called from its triple origin and its peculiar function of being the sole extensor muscle of the forearm. It is situated at the back of the arm. The *long* or *middle head* arises by a strong thick tendon from the infra-glenoid depression and the lower portion of the glenoid ligament. It is closely connected with the capsule of the shoulder-joint. As it passes between the tendons of the teres

minor and major muscles (page 329) it becomes more fleshy. The *outer head* begins immediately below the attachment of the teres minor muscle, and is itself attached all the way to the musculo-spiral groove and to the reflection of the deep fascia. The *inner head* arises close to the insertion of the teres major muscle, and from the posterior surface of the humerus below the musculo-spiral groove nearly as far as the internal epicondyle. Its fibres arrange themselves into an oblique tendon which blends with the muscular mass composed by the union of the fleshy portions of the other two heads about the middle of the back of the arm. The combined tendon thus formed is thick and remarkably strong. It is inserted into the summit and sides of the olecranon process of the ulna. Between the tendon and the back part of the capsule of the elbow-joint there is a cushion of fatty tissue, which has sometimes been described as a bursa. From the tendinous portion of the inner head some muscular fibres pass directly to the olecranon and the adjacent portion of the capsule, and have been specialized as the *subanconeus muscle.* The musculo-spiral nerve separates the outer from the inner heads, and sends branches to all the heads of the triceps muscle.

The brachial artery is the continuation downward of the axillary artery. It commences at the lower border of the posterior fold of the axilla, at the inner border of the coraco-brachialis muscle, whence it passes along the inner border of the biceps muscle to the middle of the flexure of the elbow, where, opposite the head of the radius, it divides into the radial and ulnar arteries. The above muscles slightly overlap the artery in its course, which is at first internal to the shaft of the humerus upon the triceps and brachialis anticus muscles and subsequently gradually inclines to the front of the lower end of the bone beneath the bicipital semilunar fascia. The brachial artery gives off seven or eight muscular branches from its outer side to the contiguous muscles, and four principal branches from its inner side, as follows:

The *superior profunda artery* usually arises from the brachial below the teres major muscle, although it is sometimes given off in common with the posterior circumflex from the axillary. Soon after its origin it distributes *muscular branches* to the deltoid, the coraco-brachialis, and the

long head of the triceps muscle; also a *communicating branch* to the posterior circumflex, which plays an important *rôle* in the collateral circulation after ligature of the main vessel in this locality, and a *nutrient branch*, which enters the upper end of the humerus beneath the outer head of the triceps. About the middle of the arm the superior profunda subdivides into two principal branches, one of which, the *cubital*, descends through the substance of the triceps muscle to the olecranon process, where it anastomoses with the anastomotica magna, posterior ulnar, and interosseous recurrent arteries, assisting in the formation of the *rete olecrani;* while the other branch accompanies the musculo-spiral nerve to the outer side of the arm, where, after piercing the intermuscular septum, it descends deeply with the radial nerve in the furrow between the brachialis anticus and supinator longus muscles to anastomose with the radial recurrent artery about the external epicondyle.

The *inferior profunda artery* arises either in common with the superior profunda or by a separate origin at the middle of the arm, and pursues a course with the ulnar nerve through the intermuscular septum to the interval between the internal epicondyle and the olecranon, where it also terminates in the rete olecrani. The *main nutrient artery* is usually derived from one of the muscular branches of the brachial. It pierces the tendon of the coraco-brachialis muscle to enter the nutrient foramen, and within the medullary canal divides into ascending and descending branches which anastomose with the nutrient vessels derived from the periosteum. The *anastomotica magna* arises from the brachial about six centimetres, or two and a half inches, above the bend of the elbow. It runs at first inward across the brachialis anticus muscle, and then divides into branches, one of which descends anteriorly between the brachialis anticus and pronator radii teres muscles in front of the internal epicondyle to anastomose with the anterior ulnar recurrent artery, another pierces the intermuscular septum posteriorly to anastomose with the posterior ulnar recurrent and inferior profunda arteries in the rete olecrani, while a third usually arches over the olecranon fossa and joins the superior profunda artery. Besides these regular branches of the brachial artery there is another, called the *vas aberrans*, which ordinarily is quite insignificant

and arises near the origin of the superior profunda or in common with it, and descends *over* the median nerve to supply the neighboring part of the biceps muscle. This vessel occasionally plays an important *rôle* in replacing the brachial artery when that vessel has undergone some modifying change in consequence of interference with its development during fœtal life. In such cases it pursues the ordinary course of the brachial artery, except that it is placed over instead of under the median nerve, and it joins the radial artery, or very rarely the ulnar. It is of variable size, and, owing to its substituting one or other of the terminal branches of the main vessel, it occasions the condition called the *high bifurcation* of the brachial. The possibility of such an occurrence should never be lost sight of in the operation of tying the brachial artery. The *line of reference for the brachial artery* is practically a continuation of the line for the axillary artery (page 343), and may be drawn along the internal bicipital depression from the middle of the axillary space to the middle of the bend of the elbow. The incision should be made along the above line, with the arm abducted and rotated outward. The basilic vein (page 351) will be found in the superficial fascia, and can be drawn aside. The deep fascia should be divided upon a grooved director, and when the biceps muscle has been drawn outward the sheath of the brachial vessels will be exposed, with the median *nerve* lying directly over it; and, as the nerve may therefore receive pulsations from the artery, it requires careful examination lest it be mistaken for the vessel itself.

After much experience as a teacher of operative surgery, the author feels justified in stating that the inexperienced generally find more difficulty in securing the brachial artery properly than in securing any other artery in the body. This may be due to the belief that the task is an easy one, owing to the straight course and somewhat superficial position of the vessel. The disposition of the median nerve is most important, and if understood it may serve as a deep guide to the artery. This nerve in the upper part of the arm is generally at the *outer* side of the artery, but it very soon approaches the sheath of the brachial vessels and overlies it as far as the semilunar bicipital fascia, where the artery passes to the middle of the elbow-joint, and the nerve continues, at its

inner side, to descend between the two heads of the pronator radii teres muscle. There is an investment of the deep fascia which retains the nerve in this relation to the sheath of the vessels even if the position of the arm is changed in extension, but if the forearm is flexed after the deep fascia is divided the nerve can be drawn to one side or the other and the underlying sheath exposed. When the latter is opened, the artery will be found with a companion vein upon each side of it. It should be further remembered that the upper part of the artery is *over* the musculo-spiral nerve, that the ulnar nerve is close to its inner side as far as the insertion of the coraco-brachialis muscle, and that toward the elbow the internal cutaneous nerve is either in front of or close to its inner side.

The *venæ comites of the brachial artery* are the continuations of the deep radial and ulnar veins (Plate 46, Fig. 2). The internal is usually much larger than the artery, and often overlaps it. They are frequently united by cross veins, similar to those about the axillary artery, either in front of or behind the artery, and they unite in a single trunk in the axilla to empty into the axillary vein near the tendon of the sub-scapularis muscle.

The *terminal branches of the brachial plexus of nerves* (page 344) are the median, the musculo-cutaneous, the ulnar, the two internal cutaneous, and the musculo-spiral nerves. The *median nerve* is composed of a *plexiform* arrangement of fibres derived from two heads which arise respectively from the outer and inner cords of the brachial plexus and unite to form a single nerve-cord external to the axillary artery, generally beneath the pectoralis minor muscle (Plate 45, Fig. 2, No. 23). In its course down the arm the median nerve does not normally give off any branches. It is usually at first at the outer side of the artery, near the axilla, although not always so, and it soon overlies the sheath of the brachial vessels until it reaches the elbow, where it is at the inner side of the artery, as already described. The deep fibres of origin to the outer head of the median nerve are derived from the sixth and seventh cervical nerves, and those to the inner head are derived from the eighth cervical and first dorsal nerves. The *musculo-cutaneous nerve* arises from the outer cord of the brachial plexus in common with the external head of the

PLATE 48.

Figure 1.

Dissection of the palm of the right hand, showing the superficial layer of the palmar fascia.

1. The abductor pollicis muscle.
2. Slip of the palmar fascia, passing to the proximal phalanx of the thumb.
3. Lateral nerve to the thumb.
4. Accessory transverse slip of the palmar fascia, arching over the vessels and nerves to the thumb.
5. The princeps pollicis artery.
6. The superficial layer of the palmar fascia, showing its longitudinal fibres and expansion.
7. Arch of the palmar fascia, between the metacarpal bones of the index and middle fingers, over the digital vessels and nerves.
8. Tendon of the palmaris longus muscle.
9. The ulnar artery, at the wrist.
10. The abductor minimi digiti muscle.
11. The external lateral nerve and artery to the little finger.
12. Arch of the palmar fascia, between the little and ring fingers.
13. The branches of the median nerve.

Figure 2.

Dissection of the palm of the right hand. The superficial layer of the palmar fascia is hooked aside to show the deep layer of the fascia and the *superficial* palmar arterial arch.

1. The superficialis volæ artery.
2. The abductor pollicis muscle.
3. The continuation of the superficialis volæ artery.
4. The deep layer of the palmar fascia, over the median nerve and the flexor tendons.
5. The flexor brevis pollicis muscle.
6. The superficial palmar arch.
7. Digital branches of the median nerve.
8. The superficial layer of the palmar fascia, hooked aside.
9. Branches of the median nerve, dividing at the cleft of the fingers into digital nerves.
10. The annular ligament.
11. The ulnar artery.
12. The ulnar nerve.
13. The abductor minimi digiti muscle.
14. Branches of the median nerve.
15. The external lateral artery to the little finger.
16. Branch of the superficial palmar arch.
17. Tendinous insertion of the palmar fascia to the metacarpal bone of the ring finger.
18. Superficial flexor tendon to the ring finger.
19. Digital nerves from the median nerve.

Figure 3.

Dissection of the palm of the right hand, showing the position of the superficial arterial arch and the relations of its digital branches to the nerves and flexor tendons.

1. The flexor carpi radialis tendon.
2. The median nerve, above the annular ligament.
3. The abductor pollicis muscle.
4. The median nerve, below the annular ligament.
5. The princeps pollicis artery.
6. The flexor tendon to the index finger.
7. Aponeurotic arch.
8. Sheath of flexor tendons.
9. Aponeurotic arch.
10. The subdivision of the superficial flexor tendons, to be inserted in the sides of the second, or intermediary, phalanx.
11. Anastomosing branches of the digital arteries, across the phalangeal joint.
12. Aponeurotic arch.
13. Terminal arterial plexus.
14. The ulnar artery.
15. The annular ligament.
16. The ulnar nerve.
17. The superficial palmar arch.
18. Superficial flexor tendon.
19. Aponeurotic arch of the flexor tendon to the ring finger.
20. Deep flexor tendon of the ring finger.

Figure 4.

Dissection of the palm of the right hand. The tendons are cut away to show the *deep* palmar arterial arch and its relations, etc.

1. The median nerve, above the annular ligament.
2. The opponens pollicis muscle.
3. The abductor pollicis muscle.
4. The superficialis volæ artery.
5. The flexor brevis pollicis muscle.
6. Branch of the median nerve to the thumb.
7. The adductor pollicis muscle.
8. The tendon of the flexor longus pollicis muscle.
9. The cut ends of the flexor tendons.
10. Sheath of the flexor tendons.
11. Aponeurotic arch.
12. Terminal arterial plexus.
13. The ulnar nerve.
14. The ulnar artery.
15. The annular ligament.
16. The median nerve, below the annular ligament.
17. The flexor brevis minimi digiti muscle.
18. The deep palmar arch.
19. The superficial palmar arch.
20. The cut ends of the flexor tendons.
21. Aponeurotic arch.
22. Insertion of superficial flexor tendon into the sides of the intermediary phalanx of the ring finger.
28. Terminal arterial plexus.

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median nerve, at the outer side of the axillary artery. It pierces the coraco-brachialis muscle and passes obliquely to the septum between the biceps and brachialis anticus muscles. Above the outer side of the elbow the nerve pierces the deep fascia between the tendon of the biceps and supinator longus muscles, and becomes subcutaneous beneath the median cephalic vein (Plate 46, Fig. 1, No. 9). It supplies branches to the coraco-brachialis, the coracoid head of the biceps, and the brachialis anticus muscles. This nerve is sometimes derived from the median nerve, or, if it is absent, the median nerve distributes the branches ordinarily supplied by it,—the whole of the outer cord of the brachial plexus, in such instances, contributing to the formation of the median. Division of the musculo-cutaneous nerve at its origin will result in paralysis of the flexor muscles at the elbow. Its fibres have been traced to the fifth and sixth cervical nerves.

The *ulnar nerve* arises from the inner cord of the brachial plexus in common with the internal head of the median nerve and the internal cutaneous nerve. In its course normally this nerve gives off no branches in the arm. At first it is internal to the brachial artery, but it soon leaves it to accompany the inferior profunda artery, with which it pierces the intermuscular septum fourteen centimetres, or about five inches, above the elbow, and descends on the inner head of the triceps muscle to reach the space between the internal epicondyle and the olecranon. Here it is accommodated in a shallow groove upon the back of the epicondyle (page 348), and can be felt through the skin.

The *internal cutaneous nerve*, after its origin from the inner cord of the brachial plexus, descends at first beneath the deep fascia on the inner side of the brachial artery. About the middle of the arm it pierces the fascia at the *hiatus semilunaris*, which also admits the basilic vein (page 351), and divides into anterior and posterior branches. The *anterior branch* passes under the median basilic vein and supplies the skin on the forearm as far as the wrist, where it communicates with cutaneous branches of the ulnar nerve. The posterior branch soon subdivides into several branches, one of which is distributed to the back of the internal epicondyle and communicates with the lesser internal cutaneous

nerve, and another to the back of the forearm as far as the wrist, above which there is a connection between it and the ulnar nerve. The fibres composing both the ulnar and the internal cutaneous nerves are originally derived from the eighth cervical and first dorsal nerves. The *lesser internal cutaneous nerve* (*of Wrisberg*) arises also from the inner cord of the brachial plexus, receiving its filaments from the first dorsal nerve. It is at first upon the inner side of the axillary vein, and near the anterior fold of the axilla it usually unites with the posterior division of the lateral cutaneous branch of the second intercostal nerve, or *intercosto-humeral nerve* (page 339): the compound nerve thus formed pierces the deep fascia and supplies the skin of the inside of the arm as far as the elbow.

The *musculo-spiral nerve* arises from the posterior cord of the brachial plexus, in common with the circumflex nerve (page 346), their original filaments being derived from the sixth, seventh, and eighth cervical and first dorsal nerves. The musculo-spiral nerve is the largest of the nerves of the arm. It descends behind the upper part of the brachial artery and passes between the external and the internal heads of the triceps muscle, winding obliquely round the back of the shaft of the humerus with the superior profunda artery in the musculo-spiral groove. Thence it pierces the intermuscular septum and enters the furrow between the brachialis anticus and supinator longus muscles, both of which it supplies upon the outer side of the lower third of the arm, where it divides into two terminal branches, the radial and posterior interosseous nerves. In the first part of its course, behind the brachial artery, the musculo-spiral nerve gives off branches as follows: the *nerve to the long head of the triceps;* the *posterior internal cutaneous nerve,* which supplies the area of skin behind that supplied by the intercosto-humeral nerve; the *nerve to the inner head of the triceps,* from which a little branch sometimes passes to join the ulnar nerve; the *nerve to the anconeus muscle;* the *nerve to the outer head of the triceps;* and the *posterior external cutaneous nerve,* which usually arises from the main nerve within the musculo-spiral groove and subdivides into two branches, the *superior* of which becomes superficial below the deltoid insertion and supplies the skin of the arm between that point and the elbow external to the cephalic vein. The

inferior branch descends within the superficial fascia of the forearm and supplies the skin over the ulna (page 378). It is interesting to note that the musculo-spiral nerve supplies *all* the extensor and *all* the supinator muscles, except the biceps. In consequence of its close connection with the humerus, this nerve is frequently injured by contusions, or in fractures at the middle of the shaft of the bone.

Fracture of the shaft of the humerus is a very common accident, both from direct and from indirect violence, but much undue stress has been laid upon the influence of muscular action upon the displacement of the fragments of the bone. In fact, marked displacement is rarely met with, notwithstanding the possibilities usually ascribed to the injury with reference to its occurrence above or below the insertion of the deltoid muscle. The weight of the arm tends to overcome displacement, and seldom allows much shortening. In the treatment of all fractures of the arm it is of the utmost importance that both the shoulder-joint and the elbow-joint should be properly supported, so as to maintain the fragments *in perfect line. Non-union* would probably be far less common if this were understood. *In amputation through the middle* of the arm by the antero-posterior oval-flap method, the relations of the important parts as they appear in the flaps when made upon the *left* arm are as follows (Plate 51, Fig. 1). The anterior flap consists chiefly of the biceps muscle (No. 1), while the posterior flap is composed chiefly of the triceps muscle (No. 5), containing the anastomotica magna artery (No. 11). Between the flaps on the inner side are the ulnar nerve (No. 4), the median nerve (No. 3), and the brachial vessels (No. 8). On the outer side, in the angle between the flaps will be found the severed superior profunda artery (No. 9) and the musculo-spiral nerve (No. 10).

At birth the *ossification of the shaft of the humerus* is nearly completed, although the extremities are entirely cartilaginous. Bone is not developed in the head before the second year, or in the tuberosities before the third year. There is generally but one centre of ossification for the two tuberosities, but there may be one for each tuberosity. The bicipital groove is produced by the constant and forcible impression of the long tendon of the biceps muscle on the growing bone. About the fifth year the centres

for the head and tuberosities coalesce and form the upper epiphysis, which is not united to the shaft until about the twenty-second year. The radial portion of the articular surface of the lower end of the humerus is developed by a centre of ossification in the third year, and the ulnar surface does not begin to ossify before the twelfth year. The internal epicondyle is formed about the fifth year, and the external epicondyle in the fourteenth year. The epicondyles and the trochlear surface become united about the seventeenth year and form the lower epiphysis, which generally unites with the shaft a year later. It should be noted that after the sixteenth year the growth of the humerus chiefly depends upon the upper epiphysis.

THE REGION OF THE ELBOW.

The elbow is formed by the lower end of the humerus and the upper end of the ulna, which are so adapted to each other that they establish a hinge-joint of very considerable strength, by which the arm is connected with the forearm. The peculiar conformation of the lower end of the humerus has already been described (page 348). The upper end of the ulna is one of the most remarkable portions of the skeleton, and possesses many singular features. It consists of two conspicuous processes separated by a deep hollow. The process which extends backward is called the *olecranon*, because it forms the prominence of the elbow. It is a thick, strong, bony eminence ending in a curved tip which is received into the olecranon fossa of the humerus when the forearm is extended. The base of the olecranon process is constricted where it joins the shaft, corresponding to the line of the olecranon epiphysis, and is the usual seat of fracture when this part of the bone is broken. The upper posterior surface of the olecranon is somewhat square-shaped, and presents a rough impression for the attachment of the triceps muscle (page 354). The anterior surface is smooth, and forms the upper part of the deep hollow called the *greater sigmoid cavity*, which articulates with the trochlear surface on the humerus. The bottom of this cavity is marked transversely by a line, which indicates the constriction at the base of the olecranon above referred to. The cavity terminates below in the *coronoid process*, the broad projection from the shaft of the ulna which

curves upward and ends in a point which rests in the coronoid fossa of the humerus when the forearm is flexed. The base of the coronoid process is thick and directly continuous with the shaft of the ulna. There is no epiphysis for this process, and its fracture is hardly possible. The brachialis anticus muscle is attached to the base of the process and contiguous part of the shaft. Upon the outer surface of the coronoid process there is a narrow oblong hollow, called the *lesser sigmoid cavity*, in which the adjacent head of the radius rolls. The upper end of the radius, although it is present within the elbow-joint, does not properly take part in the function of that joint. The contiguous portions of the elbow are peculiarly adapted to the retention of the upper end of the radius in position, so that the function which it possesses in relation to the hand through the wrist-joint may be maintained and act harmoniously with the movements at the elbow. The upper end of the radius is called its *head*. It consists of a round disk with a cupped depression which glides upon the capitulum on the outer condyloid surface of the humerus. The inner part of the marginal surface of the head is held in contact with the lesser sigmoid cavity of the ulna, in the ordinary position of the forearm, by means of the orbicular ligament. In the rotation of the radius the greater part of the margin of the head may revolve within the cavity. Below the head the bone is cylindrical and constricted, forming the *neck*, which joins the shaft at the prominent *tubercle* on the inner side of the bone, at the posterior and under surface of which the tendon of the biceps muscle is attached.

The elbow-joint is a *ginglymus* or *hinge joint*. The sigmoid cavities of the ulna and the trochlear surface of the humerus are covered with a layer of articular cartilage, as are also the depression and margin of the head of the radius. As stated above, the latter is present at the elbow in order merely that its function of rotation may be properly adjusted to the contemporaneous movements of the ulna. It is therefore not attached to the humerus by any special ligament, but with the ulna it is firmly held in close relation by the *orbicular ligament*, which forms a sort of collar round the neck of the radius, its ends being attached to the anterior and posterior borders of the lesser sigmoid cavity. This constitutes the

superior radio-ulnar joint, the chief function of which is to prevent the biceps muscle from dislocating the radius forward. The lower margin of the orbicular ligament is quite straight, and much narrower than the upper part, which is looser and blends with the fibres of the anterior and external portions of the capsular ligament surrounding the elbow. The *capsular ligament* is of unequal density, and is attached to the humerus over the coronoid fossa in front, to the margins of the olecranon fossa behind, and on each side to the lower surface of the epicondyles. Below, the capsule is attached to the ulna on the external borders of the olecranon and coronoid processes, and to the inner edge of the greater sigmoid cavity, and externally it is connected with the upper part of the orbicular ligament.

The capsular ligament is strengthened by accessory fibres, which are sometimes specialized as anterior, posterior, internal lateral, and external lateral ligaments. They are inseparable from the rest of the capsule, but it is important to note their peculiarities, as they in a measure limit the extent of motion at the joint. The *anterior ligament* consists of an oblique band of fibres extending from the internal epicondyle to the outer part of the coronoid process and the adjacent orbicular ligament. They assist in preventing over-extension. A few of the fibres of insertion of the brachialis anticus muscle are attached to this part of the capsule, so that in flexion the latter is drawn upward from between the bones. The *internal lateral ligament* consists of strong fibres which pass from the internal epicondyle in a radiating manner, some being attached to the coronoid process and some to the olecranon process, while a small band of fibres extends transversely between the two processes across the internal notch of the greater sigmoid cavity, thus affording protection to the small vessels which here enter the joint. From the internal lateral ligament the flexor sublimis digitorum muscle arises (page 381). The fibres composing the *external lateral ligament* pass from the external epicondyle to the orbicular ligament, and receive the origin of the extensor communis digitorum and supinator brevis muscles. The *posterior ligament* is very weak, and is composed of thin, loose fibres which extend over the back of the joint from the margin of the olecranon fossa to the borders of the olecranon process. As some of the deep fibres of the triceps are inserted

into it, it is drawn upward with the contraction of that muscle. When the capsule is opened, several quite large fatty masses are usually found contained within the folds of the synovial membrane, and occupying the several fossæ on the end of the humerus and the notches at the sides of the greater sigmoid cavity of the ulna. The *synovial membrane* lines the entire capsule, and is widest and loosest beneath the tendon of the triceps muscle, as is demonstrated by the enlargement on each side of the olecranon in cases of synovitis. It is well to note here also that in all cases of chronic distention of the elbow-joint from disease the position of semi-flexion is assumed, which naturally enables the joint to hold the greatest amount of fluid. The inner surface of the orbicular ligament is also provided with a reflection of the synovial membrane, which facilitates the rotation of the head of the radius. There are several smaller folds of the membrane in relation to the orbicular ligament. One projects between the head of the radius and the capitulum, and another between the lower border of the lesser sigmoid cavity and the neck of the radius. The latter restrains somewhat the movements of pronation and supination. The movements of flexion and extension at the elbow are probably not hindered by the olecranon and coronoid processes of the ulna, because their respective fossæ on the humerus receive them completely; but the ligaments and tendons in front of and behind the joint exert a considerable degree of restraint. A knowledge of this fact is of great importance in the treatment of all injuries about the elbow, as the thickening resulting from plastic inflammation occurring in such cases about these ligaments and tendons is very apt to produce ankylosis. It is one of the reasons why early and repeated passive motion should be resorted to upon the subsidence of acute inflammatory symptoms in every case of sprain or fracture at the elbow.

In consequence of the *obliquity* of the trochlear surface of the lower end of the humerus, when the elbow is extended and the hand supinated the forearm diverges from the line of the arm at an angle of about ten degrees. A line drawn through the epicondyles on the lower end of the humerus will form a right angle with the axis of the arm, but an obtuse angle with the axis of the forearm. This explains why in flexion the

PLATE 49.

Figure 1.

Dissection of the muscles of the right forearm and hand in pronation to show the relations of the extensor tendons of the thumb to the radial artery.

1. The tendon of the biceps muscle.
2. The supinator longus muscle.
3. The extensor radialis longior muscle.
4. The extensor communis digitorum muscle.
5. The tendon of the extensor radialis brevior muscle.
6. The posterior annular ligament.
7. The tendon of the extensor secundi internodii pollicis muscle.
8. The tendon of the extensor radialis longior muscle.
9. The tendon of the extensor indicis muscle.
10. The tendon to the index finger from the extensor communis digitorum muscle.
11. The tendon of the middle finger.
12. The flexor carpi radialis muscle.
13. The flexor sublimis digitorum muscle.
14. The tendon of the flexor carpi radialis muscle, at the wrist.
15. The extensor ossis metacarpi pollicis muscle.
16. The extensor primi internodii pollicis muscle.
17. The radial artery.
18. The abductor brevis pollicis muscle.
19. One of the tendons of the adductor interosseous muscle to the middle finger, blending with the tendon of the common extensor muscle.

Figure 2.

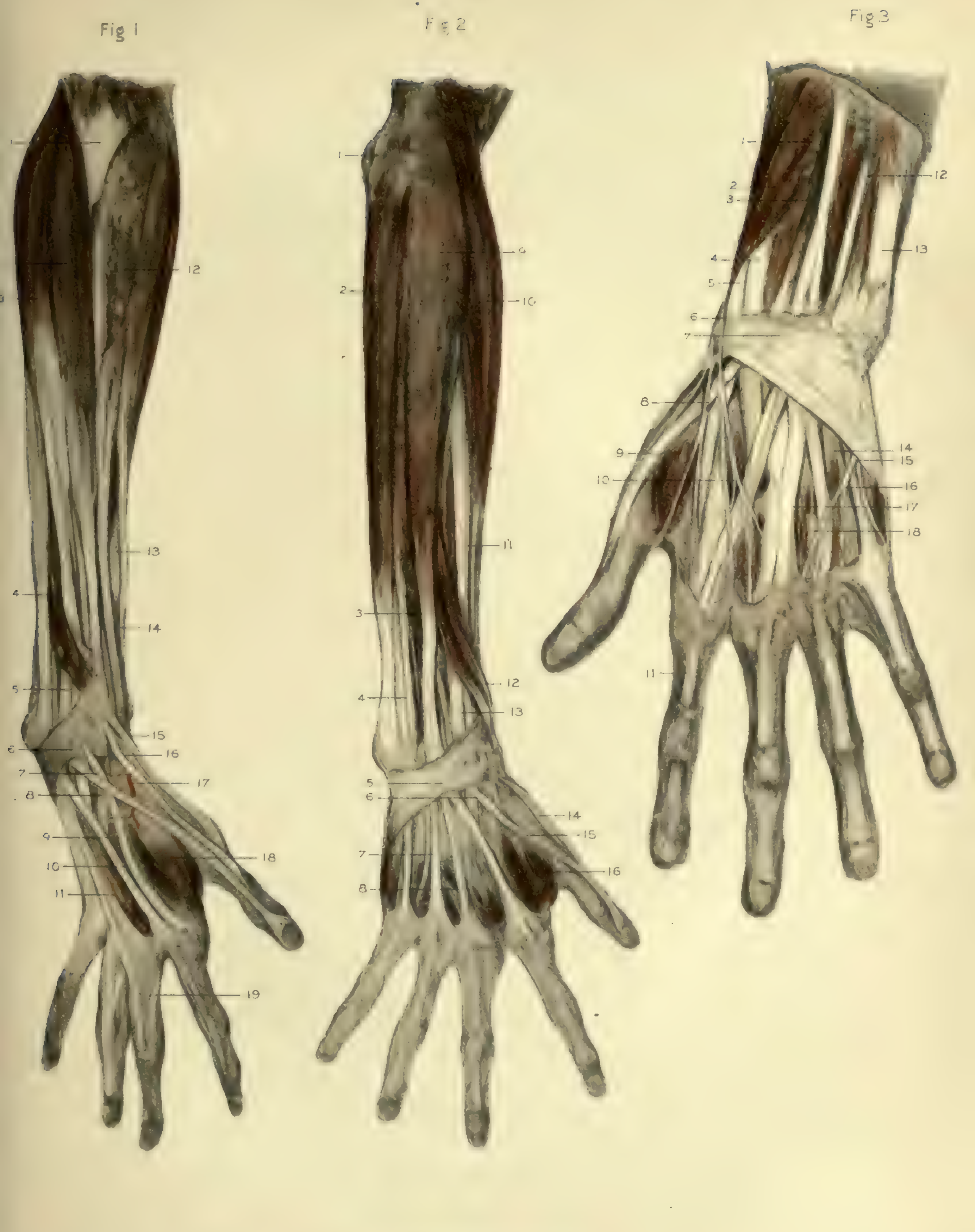
Dissection of the muscles and tendons of the back of the right forearm and hand, in extension.

1. The internal condyle of the humerus.
2. The extensor carpi ulnaris muscle.
3. The extensor communis digitorum muscle.
4. The extensor minimi digiti muscle.
5. The posterior annular ligament.
6. The tendon of the extensor radialis brevior muscle.
7. The tendon to the little finger from the common extensor muscle.
8. The tendinous slip connecting the tendons to the middle and ring fingers.
9. The extensor communis digitorum muscle.
10. The supinator longus muscle.
11. The extensor carpi radialis longior muscle.
12. The extensor ossis metacarpi pollicis muscle.
13. The tendon of the extensor radialis brevior muscle.
14. The extensor primi internodii pollicis muscle.
15. The extensor secundi internodii pollicis muscle.
16. The abductor pollicis muscle.

Figure 3.

Dissection of the tendons on the back of the left hand, showing the relations of the nerves and arteries.

1. The extensor ossis metacarpi pollicis muscle.
2. The extensor primi internodii pollicis muscle.
3. The extensor secundi internodii pollicis muscle.
4. The tendon of the extensor carpi radialis brevior muscle.
5. The tendon of the extensor carpi radialis longior muscle.
6. Branches of the radial nerve to the thumb and index finger.
7. The posterior annular ligament.
8. The common nerve to the adjacent sides of the thumb and index finger.
9. The abductor pollicis muscle.
10. The nerves to the adjacent sides of the index and middle fingers.
11. The tendon of the index finger in its aponeurotic sheath.
12. The extensor carpi ulnaris muscle.
13. The shaft of the ulnar.
14. The third dorsal interosseous muscle.
15. The branches of the ulnar nerve to the ring and little fingers.
16. Common nerve to the adjacent sides of the ring and middle fingers.
17. The tendon to the middle finger from the common extensor muscle.
18. One of the dorsal interossei arteries.



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forearm inclines inward, so that the hand is brought toward the middle line of the body, and also why it is not possible for the hand to be placed flat upon the shoulder of the same side. When the forearm is extended, the epicondyles of the humerus and the olecranon process of the ulna will be found to lie in a direct transverse line, but when it is flexed these points form a triangle, the olecranon being brought forward in front of the transverse line through the epicondyles. The olecranon process is nearer to the internal than to the outer epicondyle. When the olecranon is very prominent, its summit will be found in extreme extension above the transverse line. These bony prominences constitute the chief *landmarks* of this region, and, as they can always be felt through the skin, their relation in flexion and extension, as above indicated, should be carefully noted in all injuries to the elbow. It may also be observed that here, as in all other joints, much uncertainty may be removed by reference to the similar features upon the opposite limb.

The skin over the front of the elbow is very thin and fine, and, although there may be more or less fat in the subcutaneous tissue, the relations of the tendon of the biceps muscle can generally be easily recognized; whereas behind, over the olecranon, the skin is loosely attached with a thickened and roughened cuticle, which in extension is puckered into transverse wrinkles. In front of each elbow there is upon the outer side a prominence corresponding to the bulging of the mass formed by the supinator longus and extensor muscles, and upon the inner side there is a prominence caused by the pronator radii teres and flexor muscles. Between these the tendon of the biceps muscle descends into the *ante-cubital fossa,* thus formed, and in well-developed arms a groove is noticeable extending upward on each side of the tendon to blend respectively with the outer and inner bicipital depressions. The outer border of the tendon of the biceps can be distinguished better than the inner, owing to the reflection from the latter of the semilunar bicipital fascia.

The superficial veins at the bend of the elbow, usually described as presenting an **M**-shaped figure, are not always so arranged, because the veins are liable to great diversity in their disposition (Plates 45, 46, and 47) over the bicipital fascia. The deviation is most common

upon the radial side, in consequence of the radial tributary veins being deficient. Ordinarily the radial veins from the radial side of the forearm pass upward to empty into the cephalic vein (page 349), and the ulnar veins empty into the basilic vein (page 351), while the *anterior median vein* ascends from the wrist to the bend of the elbow, where, after receiving the blood from the deep veins of the forearm by means of the *vena anastomotica* (Plate 46, Fig. 2, No. 10, and Plate 47, Fig. 2, No. 16), it divides into two branches, respectively known as the median basilic and median cephalic veins. The *median basilic vein* generally occupies the inner bicipital groove and joins the posterior ulnar vein above the internal epicondyle as it empties into the basilic vein, while the *median cephalic vein* follows the outer bicipital groove and joins the radial veins to form the cephalic vein. These veins can usually be distinguished through the integument if there is not a great deal of fat. The median basilic vein, owing to its larger size, its prominence, and its comparatively fixed relations, has been usually selected for venesection in this region. Its course is over the bicipital fascia, and corresponds so closely to that of the brachial artery beneath the fascia that it may in some thin individuals receive the pulsations from the artery.

The strength and denseness of the bicipital fascia depend upon the general muscular development, as is the case with the expansions of the deep fascia elsewhere. Occasionally at the elbow *two* median basilic veins are found (Plate 46). Branches of the internal cutaneous nerve usually pass close to the inner side of the median basilic vein, while filaments of the musculo-cutaneous nerve pass to the skin of the forearm at its outer side. Beneath the superficial fascia the relations of the vessels and nerves on either side of the tendon of the biceps muscle are of great interest. In the outer groove between the tendon and the supinator longus muscle are the terminations of the musculo-cutaneous and musculo-spiral nerves, and the superior profunda and radial recurrent arteries (Plate 46, Fig. 1, No. 10). In the inner groove beneath the bicipital fascia are the median nerve, the brachial artery and its two companion veins, and the communication between the anastomotica and anterior recurrent ulnar arteries. The *median nerve at the elbow* is at the *ulnar* side of the brachial artery, and

descends beneath the fascia between the two heads of the pronator radii teres muscle (page 379), having previously distributed branches to the superficial flexor muscles and to each head of the pronator. The *brachial artery at the elbow* passes beneath the bicipital fascia to the middle of the joint, where opposite the head of the radius it bifurcates into the radial and ulnar arteries. As the brachialis anticus muscle passes over the elbow-joint to be inserted into the coronoid process of the ulna, it supports the termination of the brachial artery, besides serving as a covering to the joint. In forcible flexion of the elbow it is possible effectually to compress the artery between the masses of muscle, but such pressure, necessarily involving the median nerve also, is so painful that it cannot be endured more than a short time. When the bicipital fascia is removed, the origins of the *brachial veins* from the deep venæ comites of the vessels of the forearm and their relations to the brachial artery are exposed (Plate 46, Fig. 2, No. 8). Between the olecranon process and the internal epicondyle the ulnar nerve is lodged in a groove, which is subcutaneous (page 359). It is in close relation with the posterior recurrent ulnar artery. Sometimes the ulnar nerve passes in front of the epicondyle instead of behind it. Just below the external epicondyle there is a depression which is always to be seen even when there is much fat in the subcutaneous tissue. This depression adds much to the graceful contour of this part of the forearm, and it is most marked when the latter is extended. The depression corresponds to the interval between the supinator longus and extensor carpi radialis muscles and the external border of the anconeus muscle. It is important surgically, as the head of the radius can be felt in it when the bone is rotated, and because it thus affords a means of distinguishing the line of the elbow-joint. If the forearm is placed in the position of extreme pronation, the tubercle of the radius can be felt below the head. The *superficial lymphatic vessels of the forearm* accompany the superficial veins toward the inner side of the elbow, and terminate in a *lymphatic gland* situated just above the internal epicondyle. This gland is apt to be involved in any septic affection of the fingers or hand, and should be remembered, as it is the lowest gland in the upper extremity.

There are *three bursæ about the elbow*, one between the attachment of the tendon of the biceps and the tubercle of the radius, a small one occasionally over the internal epicondyle, and a large one over the olecranon process. The latter is frequently enlarged, and when inflamed may affect the joint, as there is a communication between it and the synovial membrane. The elbow-joint is supplied by filaments from both the ulnar and the median nerve. In some injuries to the joint severe pain is experienced in the parts of the forearm corresponding to the distribution of these nerves. The anastomoses of the arteries about the olecranon process and the posterior part of the capsule of the elbow establish the *rete olecrani.* The vessels forming it are derived from the anastomotica and superior and inferior profunda arteries, which are branches of the brachial artery, and from the posterior ulnar recurrent and interosseous recurrent arteries. It is important to note that their disposition is such that the circulation through them is not interrupted by the tension of the superficial fascia in extreme flexion of the elbow, when the current in the brachial artery at its bifurcation may be arrested by pressure. It should be observed also that the arteries about the internal epicondyle are more numerous than those about the external.

The commonest form of *dislocation* of the elbow is where the bones of the forearm are driven backward upon the lower end of the humerus. In such cases, when the displacement is complete, the coronoid process will be found opposite the olecranon fossa, with the head of the radius projecting behind the external epicondyle. The anterior and lateral ligaments of necessity are torn, the orbicular is rarely affected, and the posterior may or may not be torn, according to the nature and direction of the violence. The tendon of the biceps appears like a tense cord drawn over the trochlear surface of the humerus, while the attachment of the brachialis anticus is usually ruptured. The median and ulnar nerves are necessarily stretched.

Fractures of the lower end of the humerus which involve the elbow-joint occur most commonly in young persons. They are caused by direct violence received upon the point of the elbow. Sometimes the olecranon process is driven so forcibly into the olecranon fossa that the end of the

humerus is split across transversely at its base, or it may be complicated by a vertical separation of the condyloid portions of the bone, thereby constituting a **T**-shaped fracture. Of the two epicondyles, it may be said that the external, on account of its slight prominence and construction, is very rarely if ever broken by itself, whereas the internal often suffers fracture. The latter, prior to the age of eighteen years, may be detached at its epiphysis (page 362). There is seldom displacement following fracture of the internal epicondyle, as it is enveloped by the dense aponeuroses of the common flexor muscles of the forearm. In children, when there is a separation of the lower epiphysis of the humerus there is naturally very little deformity, in consequence of the epiphyseal line being almost wholly within the capsule of the elbow. *Fracture of the olecranon process* occurs most frequently just above the constriction through the greater sigmoid cavity, and corresponds to the epiphyseal line. The degree of displacement depends upon the extent to which the periosteum and ligaments are ruptured, and the consequent unrestricted contraction of the triceps muscle. Fracture of the coronoid process of the ulna, or of the head or neck of the radius, can hardly occur except in severe injuries attended with dislocation and extensive contusion, owing to their anatomical relations.

The relations of the parts as they are found in the flaps after *amputation at the elbow-joint* by the antero-posterior flap method (on the *left* side) are as follows (Plate 51, Fig. 2). The anterior flap is composed chiefly of the biceps and brachialis anticus muscles, and contains the severed median nerve (No. 1), and the brachial artery (No. 2) and its veins (No. 3). In relation to the internal epicondyle are the ulnar nerve and the posterior recurrent ulnar artery, while the musculo-spiral nerve is in close proximity to the external epicondyle, and the radial recurrent artery is in the outer angle of the flaps. The posterior flap is composed of the integument and the tendon of the triceps muscle (No. 12), the latter attached to the severed olecranon process of the ulna. At the inner border of the posterior flap there is a recurrent branch of the ulnar artery, and in the inner angle between the flaps is the anastomotica magna artery.

In *resection* of the elbow there is always danger of injuring the ulnar

nerve, owing to its close relation to the internal epicondyle and the difficulty of detaching the soft structures from that bony prominence. It is very important to preserve the periosteum over the olecranon and the strong fascia over the anconeus muscle, so that the triceps may not be altogether severed from the ulna. The relations of the parts exposed in the procedure by a posterior vertical incision (on the *left* side) are as follows (Plate 52, Fig. 6): the severed tendon of the triceps (No. 2) will be seen just above the trochlear surface of the lower end of the humerus (No. 3); upon the outer side of the olecranon process, which is denuded of its periosteum (No. 8), are the head of the radius (No. 4) and the radial recurrent artery (No. 5), while upon the inner side are the ulnar nerve (No. 7) and the posterior ulnar recurrent artery (No. 9).

As an illustration of the possible degree of injury which the elbow may recover from without loss of power or motion, the author may be justified in noticing in this connection a case recently under his care. The patient, a young man aged twenty-one years, received fractures of the internal epicondyle and the upper end of the ulna below the coronoid process in consequence of a fall upon the elbow while it was in a semi-flexed position. Seven weeks later, when he was regaining the use of the elbow, after constant passive motion, he met with another fall and fractured the olecranon of the same elbow through the greater sigmoid cavity. Owing probably to the passive use to which the triceps had been so recently subjected, and certainly to the extensive laceration of the ligaments and the periosteal connections, the process was drawn a hand's breadth away from its proper site. The local contusion and extravasation in both instances were unusually great, but, by careful perseverance, within two months complete use of the joint was obtained, both as to power and as to motion, and measurement proved that the olecranon was consolidated again with the ulnar shaft without any separation,—an unusual feature.

THE REGION OF THE FOREARM.

The shafts of the radius and the ulna, beyond their upper extremities, already described with the elbow, extend side by side to the wrist, and are peculiarly formed, not only to support the soft structures of the forearm,

but also to be adapted to their respective functions, the ulna being employed principally in extension and flexion, while the office of the radius is to rotate the hand in pronation and supination. The radius is external on the side of the thumb, the ulna is internal on the side of the little finger.

The *shaft of the radius* below the bicipital tubercle is prismatic in form, and gradually increases in breadth to the lower fourth of the bone, where it is expanded into a large quadrilateral-shaped extremity for articulation with the wrist. The radius is slightly bowed forward and inward, presenting an external border which is convex through its whole extent, and an internal or ulnar border which presents along its middle a sharp edge for the attachment of the interosseous ligament which connects the radius with the opposing sharp edge of the ulna. The *lower extremity of the radius* is the broadest part of the bone. It terminates in the *carpal articular surface*, which presents *two concave facets*, the outer of which is triangular, for the reception of the upper convex surface of the scaphoid bone, and the inner is quadrate, for the semilunar bone. The external border of the scaphoid facet is narrow, and prolonged downward in a conical projection, called the *styloid process of the radius.* The internal border of the semilunar facet is placed on a level considerably higher than the latter, and presents a depression for articulation with the contiguous convex border of the lower end of the ulna. The margins of the *ulnar depression* unite above and are continuous with the interosseous edge of the bone. The outer surface of the styloid process and the adjacent posterior surface of the lower end of the radius are grooved for the passage of the tendons of the extensor muscles (page 384). The articular surface of the lower end of the radius appears vertically concave, owing to the projection forward of the irregular sharp lip of bone, the *posterior crest,* which is the portion of the bone supposed to be detached from the shaft in the so-called Barton's fracture of the wrist.

The *shaft of the ulna* gradually diminishes in size from below the attachment of the brachialis anticus muscle to the lower end. It is prismatic in form, and is twisted in its axis, so that below the elbow it inclines a little toward the radius, becomes quite straight at its middle, and arches slightly away from the radius lower down, where its rounded articular

PLATE 50.

Figure 1.

The relations of the structures involved in the operation of trephining the skull, as in a case of cortical epilepsy. The disk of bone has been removed and the pia mater partially detached to expose the convolutions on the right hemisphere, supposed to include the centre of the movements of the hand, and especially of the thumb.

1. The scalp flap, including the periosteum, reflected from the bone.
2. The skull, with the temporal ridge plainly showing.
3. The upper cut end of the temporal artery.
4. The fissure of Rolando, in this case joining the horizontal branch of the fissure of Sylvius.
5. The flap of dura mater, with the cut branch of the middle meningeal artery seen through it.
6. A branch of the middle cerebral artery, lodged in the posterior part of the horizontal branch of the fissure of Sylvius.
7. A cut scalp artery, branch of the posterior temporal artery.
8. The lower cut end of the temporal artery.
9. The lower part of the anterior central, or ascending frontal, convolution.
10. The lower part of the posterior central, or ascending parietal, convolution.

Figure 2.

Amputation at the left shoulder-joint by the oval-flap method (of Larrey), showing the relations of the parts exactly as they appear after the completion of the operation. The anterior flap is formed by the pectoralis major, the heads of the biceps, the coraco-brachialis, the latissimus dorsi, the teres major, and the rotator muscles of the joint. The posterior flap is formed mainly by the deltoid muscle.

1. The axillary vein.
2. The axillary artery.
3. The cut pectoralis major muscle.
4. The glenoid cavity of the scapula, covered with its articular cartilage.
5. The glenoid, or long, head of the biceps muscle.
6. The clavicular portion of the deltoid muscle.
7. A branch of the anterior circumflex artery.
8. The cephalic vein and the descending branch of the acromio-thoracic artery.
9. One of the brachial veins.
10. The latissimus dorsi and teres major muscles.
11. The brachial plexus of nerves.
12. The inferior scapular artery and veins.
13. A portion of the capsular ligament.
14. The posterior circumflex vessels and nerve.
15. The cut deltoid muscle.
16. The position of the sub-deltoid bursa.

Fig 1

Fig 2

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surface bends back again to be received upon the depression on the inner border of the lower end of the radius. The internal border of the ulna is irregular, being rounded and smooth above and roughened below, while the external or radial border is provided with a sharp *edge*, except at the lower fourth of the bone. The lower extremity of the ulna is very small, and terminates in a hollow depression adapted to the triangular fibro-cartilage which intervenes between it and the wrist-joint. From the posterior border of the lower end, on the little-finger side, extends a small blunt-pointed bony projection, called the *styloid process of the ulna.* This is placed a little lower than the rounded bony prominence or *head* of the ulna, which is received against the depression on the radius, already mentioned, and forms the *inferior radio-ulnar joint.* This joint is completed below by the upper surface of the triangular cartilage (page 397), and is surrounded with a *capsular ligament*, which is especially loose anteriorly. Some of the fibres of this capsule have been specialized, according to their relative positions, as the *anterior* and *posterior radio-ulnar ligaments.* They are continuous with the capsule of the wrist-joint proper. The opposing surfaces of the ulna and the triangular fibro-cartilage are not moulded to each other, and the intervals between them are filled by a loose fold of synovial membrane, called the *membrana sacciformis.* The shafts of the two bones of the forearm are connected by the oblique and interosseous ligaments. The *oblique ligament* extends from the lower surface of the tuberosity of the ulna downward and outward to the shaft of the radius below the bicipital tubercle. It is not always present, and is regarded as a specialization of the fascia covering the supinator brevis muscle, which arches over the insertion of the tendon of the biceps.

The *interosseous ligament*, or *interosseous membrane*, as it is sometimes called, consists of several layers of fibres, which pass chiefly obliquely from the sharp internal edge of the radius to the contiguous border of the ulna. This ligament is deficient above, to the extent of about two and a half centimetres, or an inch, below the tubercle of the radius, so that that process can have free play in the rotation of the bone on the ulna. In relation to the extensor muscles of the thumb there are additional fibres derived from their sheaths, which cross one another between the bones of the forearm.

The interosseous ligament, besides offering a broad surface for the attachment of the deep flexor and extensor muscles (page 383), strengthens the two bones and enables the hand to support a weight or to push against an object in extension, as when the ulna and the humerus are in a direct line, constituting the *humero-ulnar shaft.* The movements of *pronation* and *supination* take place between the bones of the forearm, about an axis which corresponds to a line drawn from the head of the radius through the lower end of the ulna and the metacarpal bone of the ring finger. Pronation is mainly limited by the lower two-thirds of the interosseous ligament, the inner part of the posterior carpal ligament, and the opposition of the bones. Supination is checked partially by the lowest part of the interosseous ligament and the internal lateral carpal ligament, and partially by the catching of the posterior edge of the ulnar depression of the radius upon the tendon of the extensor carpi ulnaris muscle, which passes over the groove on the back of the styloid process of the ulna. Owing to the loose capsular ligament about the inferior radio-ulnar joint, there is always a slight lateral motion between the bones at this articulation in the rotation of the radius. It should be remembered that the *interosseous space* is larger below than above, and that it is narrowest in complete pronation and widest in supination; and, further, that the bones of the forearm can be said to be parallel to each other only when they are held half-way between pronation and supination, or when the forearm is at right angles with the arm and the palm of the hand is turned upward. In the treatment of fractures of the forearm too great attention cannot be given to the proper adjustment of the bones so as to secure the preservation of the *interosseous space* from infringement, because such infringement is almost certain to be followed by a proportionate degree of loss of the rotating power of the wrist. In this connection it should be noted that the shafts of the radius and ulna vary in size relatively to each other according as they are considered near the elbow or near the wrist, the radius increasing and the ulna decreasing from above downward. This is well seen upon section of the bones, as in an amputation anywhere in this region (Plate 51, Fig. 3). Both bones are also nearer to the posterior than to the anterior surface of the forearm through their whole extent.

The internal and posterior surfaces of the ulna are wholly subcutaneous, and the lower part of the external surface of the shaft of the radius, as well as its head, can be readily felt through the skin,—the intervening portion of the radius being covered by the thick mass composed of the supinator longus and extensor carpi radialis muscles. The shape of the circumference of the upper portion of the forearm naturally depends upon the degree of muscular development, being generally oval in the male and round in the female and the child. In both of the latter the contour of the limb is influenced by the presence of a greater proportionate amount of fat upon the anterior and posterior surfaces. The variability in the transverse width in the upper part of the forearm is chiefly due to the degree of development of the muscles which take origin from the surfaces about the epicondyles of the humerus, the mass upon the radial side being the larger, already referred to as being more pronounced upon the posterior surface. On the lower third of the radial border the extensor muscles of the thumb produce a slight elevation as they pass obliquely downward (Plate 49). Above the middle of the forearm the muscles are always more developed anteriorly than they are posteriorly, while below it, where the muscles become tendinous, the two bones are more equally covered by the soft parts both anteriorly and posteriorly.

The *skin*, like that of the arm, is thinner, more sensitive, and more loosely attached by the superficial fascia to the deep fascia on the front and inner surface of the forearm than upon the back and outer surface. The superficial veins, lymphatic vessels, and cutaneous nerves are within the layers of fatty and connective tissue which compose the superficial fascia. The *veins* can usually be readily seen through the skin, passing upward from the wrist to the elbow. On the anterior surface the *superficial median vein* ascends along the front of the forearm, while upon the ulnar surface are usually a *small superficial anterior ulnar vein* and a *larger posterior ulnar vein.* The *superficial radial veins* commence at the radial dorsal plexus of the hand and ascend by several branches over the lower part of the posterior or dorsal surface of the forearm (Plate 47, Fig. 3), and then wind round the radial border to empty with the other superficial veins into the venous trunks at the front of the elbow, already described

(page 367). Besides these there are many superficial communicating veins which connect the median with the ulnar and radial veins at different points in the front of the forearm. It is noteworthy that the dorsal surface to the extent of ten centimetres, or four inches, below the olecranon process is comparatively free from superficial veins. It is also a fact often unheeded, that the greater part of the blood from this region is returned by the surface veins, so that any undue or improperly-applied pressure by splints or bandaging may result in œdema.

The *cutaneous nerves of the forearm* are derived from the branches of the musculo-cutaneous, the external cutaneous branch of the musculo-spiral, and the internal cutaneous nerves, which supply special areas and establish communications between their ultimate filaments. On the anterior surface below the elbow, the *anterior branch of the musculo-cutaneous* (page 357) supplies the radial border of the forearm as low down as the wrist (Plate 27, No. 56). About opposite the middle of the radius this nerve gives off the *posterior* branch, which winds backward to supply the skin on the dorsal surface as far as the wrist, where it joins with filaments from the radial and external cutaneous branches of the musculo-spiral nerve. A few of the lower filaments pass across the ball of the thumb and communicate with the palmar branch from the median nerve and the radial nerve in that locality. In relation to the elevation caused by the extensor muscles of the thumb the *radial nerve becomes superficial*, and curves over the radius to supply the back of the hand and the fingers (Plate 47, Fig. 1, No. 16, and Plate 53, Fig. 2). The *external cutaneous branches of the musculo-spiral nerve* (page 360) supply some filaments to the skin over the front of the forearm which join with fibres from the *anterior division of its inferior branch*, and some filaments to the outer and back part of the forearm, from the elbow to the wrist, by the *posterior division*. On the ulnar side the *anterior* branch of the internal cutaneous nerve (page 359) supplies the strip of skin over the ulna as far as the wrist. Below the inner side of the elbow the *posterior* branch passes backward to supply the upper portions of the posterior surface of the forearm. The *dorsal* branch of the ulnar nerve becomes subcutaneous close to the styloid process of the ulna (Plate 47, Fig. 3, No. 4), and dis-

tributes filaments over the back of the hand, which join with the terminal filaments of the external and internal cutaneous nerves about the wrist.

The *deep fascia of the forearm* is directly continuous with that of the arm, and forms a dense, close-fitting aponeurotic sleeve about the soft structures, being peculiarly modified above and below so as to contribute to the power of the muscles in their contraction and to restrain and preserve the position of the tendons. It is mainly composed of obliquely decussating fibres, which are reinforced in certain localities, as in front of the elbow, by fibres from the tendons of the biceps and brachialis anticus muscles, and at the wrist, where it forms the posterior annular ligament and contributes to the anterior annular ligament. The deep fascia is further attached to all the bony processes which are subcutaneous, especially to the epicondyles, the olecranon, and the inner border of the shaft of the ulna. The under surface of this fascia divides into septa, which not only separate the individual muscles from one another but also furnish to each of them additional surfaces for the origin of their fibres. It is perforated at intervals by the various cutaneous vessels and nerves.

The muscles of the forearm are disposed in two groups, an anterior group, consisting of the flexors and pronators, which are attached about the internal epicondyle of the humerus (page 348), and a posterior, consisting of the extensors and supinators, which are attached to the external epicondyle and the condyloid ridge above it. Each group further consists of two layers, superficial and deep. The *superficial layer of the anterior group* comprises five muscles, which are arranged in the following order from within outward: the pronator radii teres, the flexor carpi radialis, the palmaris longus, the flexor sublimis digitorum, and the flexor carpi ulnaris.

The *pronator radii teres* muscle arises by two distinct portions or heads, the most *superficial* being attached to the internal supra-condyloid ridge and to the adjacent intermuscular septum, and also, sometimes, to the supra-condyloid ligament (page 351), and the deeper portion by a thin tendon from the inner side of the coronoid process of the ulna. The fibres of these two portions unite and pass obliquely to be inserted by a

flat tendon into the oblique line and the pronator impression on the outer side of the radius. This muscle forms the inner border of the ante-cubital fossa at the elbow, and is supplied by twigs from the median nerve, which descend between its two portions (page 369). The special function of the pronator teres is to rotate the radius on the ulna, in conjunction with the pronator quadratus (page 384).

The *flexor carpi radialis muscle* arises from the common tendon about the internal epicondyle, from the intermuscular septa on each side of it, and from the overlying deep fascia. Its fibres pass obliquely outward and end in a long tendon, which is at first flat and becomes narrow toward the wrist, where, after crossing over the anterior annular ligament, it continues beneath the short flexor muscles of the thumb, through a fibrous arch in relation to the trapezium, and is inserted into the base of the metacarpal bone of the index finger. In the lower part of the forearm the tendon of this muscle is at the inner side of the radial artery and its veins, the tendon of the supinator longus being at the outer side (Plate 46, Fig. 1, No. 14). Between the tendon and the trapezium there is usually a bursa. There is sometimes an accessory muscle beneath the flexor carpi radialis, which arises from the radius and is inserted into the metacarpal bone of the middle finger, being also connected with the other muscle by a few fibres at its insertion. The function of the flexor carpi radialis is to flex the wrist and to abduct the hand, or, acting from below, it may assist in flexing the elbow. It is supplied by the median nerve.

The *palmaris longus muscle* is occasionally absent, and when present is always small. Its fibres unite into a slender flat tendon, which descends usually along the middle of the forearm upon the flexor sublimis muscle to the wrist, where, after passing over the annular ligament, it becomes continuous with the palmar fascia (Plate 48, Fig. 1, No. 8). In some instances the tendon of the palmaris longus is attached to the anterior annular ligament, without extending to the palmar fascia. Its muscular portion is subject also to great variety of development. The *flexor carpi ulnaris muscle* has a double origin, from the back of the internal epicondyle by a flat tendon, and by an expansion of the fascia over the olecranon, so that they form an arch under which pass the

ulnar nerve and ulnar recurrent artery. This muscle also takes origin from the fascia attached to the upper two-thirds of the ulna. The fibres from these sources present a penniform arrangement, as they enter a tendon on the radial side, which, after passing over the anterior annular ligament, is inserted into the pisiform bone, and to the fibrous expansion stretching across the unciform bone to the base of the metacarpal bone of the little finger. In the lower two-thirds of the forearm the ulnar artery, with its companion veins and the ulnar nerve, is placed between the tendons of the flexor carpi ulnaris and flexor sublimis muscles, the former muscle in reality overlapping the artery until within a short distance above the wrist (Plate 46, Fig. 1, No. 33). In relation to the annular ligament the ulnar vessels and nerve are protected by a fibrous expansion which extends between the ligament and the tendon of the flexor carpi ulnaris. This muscle receives twigs from the ulnar nerve as the nerve passes between its two portions above. Its function is to flex and adduct the wrist.

The *flexor sublimis digitorum muscle* is situated beneath the other muscles of the superficial layer, and arises by three separate portions, —one large, tendinous, and fleshy, from the internal epicondyle and the adjacent part of the capsular ligament of the elbow and from the intermuscular septa between it and the two carpal flexor muscles; one, small and tendinous, from the inner side of the coronoid process above the pronator teres; and another, thin, broad, and fleshy, from the oblique ridge on the front of the radius, extending from the bicipital tubercle to about two and a half centimetres, or one inch, below the insertion of the pronator teres, which partly overlaps it. The fibres from these different sources combine into one muscle, which passes down the middle of the forearm and subdivides into *four* distinct slips which terminate in four tendons arranged in two superposed pairs as they pass beneath the annular ligament into the palm. The superficial pair of tendons are continued to the middle and ring fingers, while the deeper pair go to the index and little fingers. All these tendons within the palm are placed beneath the branches of the median nerve and the ulnar artery (Plate 48, Fig. 3). Each of the tendons of the flexor sublimis muscle, as it enters the aponeurotic sheath which encloses it in relation to the meta-

PLATE 51.

Figure 1.

Amputation through the middle of the left arm by the antero-posterior oval-flap method, showing the proper relations of the vessels and nerves to the humerus, in a well-developed man, aged forty-eight years.

1. The anterior flap, composed chiefly of the biceps muscle.
2. The flap of the periosteum, which was dissected from the anterior surface of the humerus before the saw was applied to the bone.
3. The median nerve.
4. The ulnar nerve.
5. The posterior flap, composed chiefly of the triceps muscle.
6. Section of the left humerus, at its middle.
7. The medullary canal of the humerus.
8. The brachial artery and veins.
9. The superior profunda artery.
10. The musculo-spiral nerve.
11. The anastomotica magna artery.

Figure 2.

Amputation at the left elbow-joint by the antero-posterior flap method (of Dupuytren), showing the relations of the severed structures immediately after the completion of the operation. The olecranon process of the ulna is retained to preserve the function of extension of the triceps muscle.

1. The median nerve.
2. The brachial artery.
3. The brachial vein.
4. The ulnar artery and the ulnar nerve.
5. The anastomotica magna artery.
6. One of the recurrent branches of the ulnar artery.
7. The anterior flap, composed chiefly of the biceps and brachialis anticus muscles.
8. The musculo-spiral nerve.
9. The radial artery.
10. The lower end of the humerus, showing the trochlear surfaces of the condyles covered with articular cartilage.
11. The section through the greater sigmoid notch of the olecranon process of the ulna.
12. The posterior flap, composed of integument and the tendon of the triceps muscle.

Figure 3.

Amputation through the middle of the left forearm by the antero-posterior oval-flap method, showing the relations of the severed structures on completion of the operation.

1. The superficial median vein.
2. The anterior flap, composed chiefly of the flexor muscles.
3. The median nerve.
4. Section through the middle of the left ulna.
5. The ulnar artery and veins, and the ulnar nerve.
6. The radial artery and veins, and the radial nerve.
7. Section through the middle of the left radius.
8. The interosseous artery and the interosseous nerve.
9. The posterior flap, composed chiefly of the extensor muscles.
10. The superficial radial vein.

N. B.—These amputations were all done by means of a long, stout, straight bistoury, applied from without inward, which gives a *bevelled* appearance to the flaps, overcomes the retraction of the skin, and renders unnecessary the after-retrenching of the muscles. In each instance the vessels were left in the wound, as they would be before the application of the ligatures, and the nerves have been left as they were severed by the knife.

Fig 2

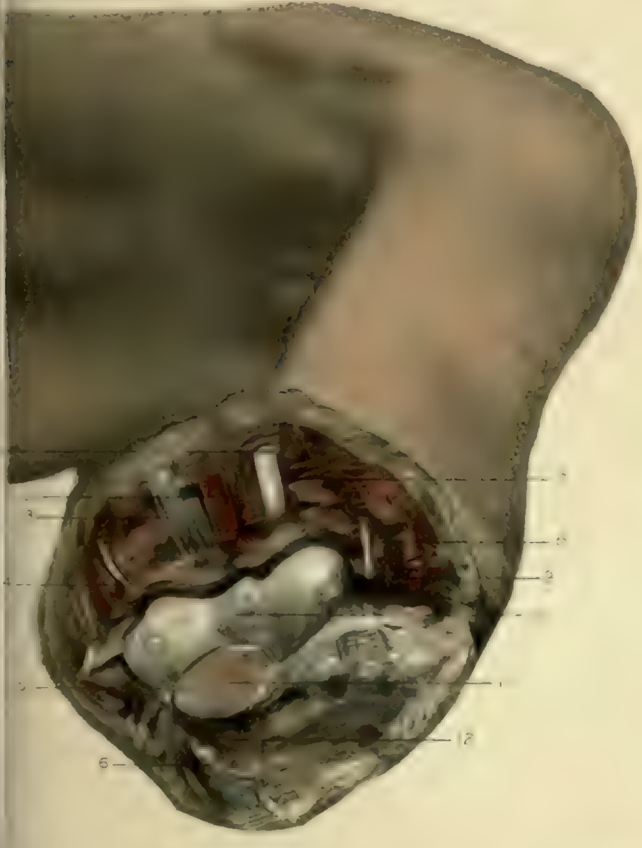


Fig 3

Photographed and Colored from Nature by George M. McClellan M.D.

carpo-phalangeal joint of its special finger, divides into two lateral slips, which diverge opposite the middle of the first or proximal phalanx so as to allow the corresponding tendon of the flexor profundus muscle to pass between them. The two lateral slips of the superficial tendon closely embrace the deep tendon, and pass behind it in such a way that their component fibres decussate before they separate again to be finally inserted into the sides of the second phalanges (page 404). The *action* of the flexor sublimis muscle is to flex the second joint of the fingers. The different portions of the above muscle are supplied by the median nerve.

The *muscles of the deep layer of the anterior group of the forearm* are the flexor profundus digitorum, the flexor longus pollicis, and the pronator quadratus. The *flexor profundus digitorum muscle* is the thickest individual muscular mass in this region. It arises from the inner two-thirds of the anterior surface of the ulna as far as the origin of the pronator quadratus muscle, and from the interosseous ligament in relation to the ulna. The fleshy mass resulting from the fibres thus arising soon divides into two portions, the outer one of which separates from the inner and main portion above the middle of the forearm and continues independently to its insertion into the index finger, while the fibres composing the inner portion are inserted into three flat tendons which pass side by side upon the same plane with their fellow-tendons to the index finger beneath the annular ligament, under the tendons of the flexor sublimis muscle. About the middle of the first or proximal phalanges of the fingers the deep tendons perforate the superficial tendons, to be inserted finally into the bases of the third or ungual phalanges (page 404). The tendons of the flexor profundus muscle serve to flex the finger-tips. Its nerves are branches of the interosseous branch of the median nerve and the ulnar nerve.

The *flexor longus pollicis muscle* arises mainly from the anterior part of the shaft of the radius, below the oblique line and above the pronator quadratus muscle, and from the adjacent part of the interosseous ligament. It sometimes also receives a few fibres of origin from the coronoid process. The fleshy fibres, becoming thicker toward the wrist, terminate in a tendon,

which passes under the annular ligament and between the two portions of the flexor brevis, to be inserted into the base of the last phalanx of the thumb. It strongly flexes the thumb, and receives its nerve from the interosseous branch of the median nerve.

The *pronator quadratus muscle* is a square muscle arising tendinously from the lower fourth of the oblique line on the ulna, and from the strong fascia covering its anterior surface. Its fibres pass transversely to their insertion into the lower fourth of the anterior surface and contiguous outer border of the radius. Its function is to pronate the radius in conjunction with the pronator teres muscle. The interosseous branch of the median nerve also supplies it.

The *muscles of the superficial layer of the posterior group of the forearm* are seven in number, and are arranged in the following order from the radial to the ulnar border: the supinator radii longus, the extensor carpi radialis longior, the extensor carpi radialis brevior, the extensor communis digitorum, the extensor minimi digiti, the extensor carpi ulnaris, and the anconeus. The *supinator radii longus muscle* arises by fleshy fibres from the external condyloid ridge of the humerus as high up as the musculo-spiral groove. It forms the outer boundary of the ante-cubital fossa of the elbow, and is the most external of the muscles covering the radial border of the forearm (Plate 49, Fig. 1, No. 2, and Fig. 2, No. 10). This muscle terminates about the middle of the forearm in a flat tendon which is inserted into the outer side of the base of the styloid process of the radius. At its insertion it is covered by the tendon of the extensor ossis metacarpi pollicis muscle (Plate 49, Fig. 2, No. 12). This muscle assists the anterior muscles in flexing the forearm, but it acts as a supinator upon the hand. It is supplied by a branch of the musculo-spiral nerve before its division.

The *extensor carpi radialis longior muscle* arises from the lower part of the external condyloid ridge and the septum intervening between it and the extensor brevior muscle. It soon ends in a flat tendon which is overlapped by the supinator longus, and, passing beneath the extensor muscles to the thumb, it traverses a groove on the outer and posterior surface of the lower end of the radius, to be inserted into the radial side of the

carpal end of the metacarpal bone of the index finger. The tendon of this muscle occupies the second groove in the posterior annular ligament. Its nerve is derived from the musculo-spiral nerve.

The *extensor carpi radialis brevior muscle* arises with the preceding muscle from about the external epicondyle, the intermuscular septa, and the adjacent part of the capsular ligament of the elbow. It is shorter and thicker than the extensor longior muscle, and its fibres terminate upon the under surface of a flat tendon below the middle of the forearm, where it is overlapped by the extensor longior. The tendon passes beneath the extensor muscles of the thumb, being accommodated in a special groove in the posterior surface of the lower end of the radius, and is inserted in the radial side of the base of the metacarpal bone of the middle finger. It is supplied by the posterior interosseous nerve. The tendons of both of the radial extensor muscles have usually small bursæ interposed between them and their insertions. They are peculiarly enclosed in a synovial sheath as they pass under the extensor muscles of the thumb, which allows them to play freely under these (page 388). Their function is to extend the wrist.

The *extensor communis digitorum muscle* arises from the lower part of the external epicondyle, the intermuscular septa, and the overlying expansion of the deep fascia. It divides on the back of the forearm into three portions, which terminate in tendons at different points and pass under the annular ligament posterior to the radius to the back of the hand, whence they are distributed to the fingers, the third tendon dividing so that it is distributed to both the ring and the little finger. Below the annular ligament the tendons become broad and flat and diverge from one another toward the knuckle-joints of the fingers, where they change in character, becoming thicker and narrower, and give off lateral expansions, which pass to the sides of these joints and thus form the *lateral metacarpo-phalangeal ligaments* (Plate 49, Fig. 2). On the back of the hand the two middle tendons generally pass over the corresponding metacarpal bones, while the tendon to the index finger passes obliquely across the space between the first and second metacarpal bones, and the tendon to the little finger, smaller than the other, continues in close relation to that of the ring finger until just above the metacarpo-phalangeal joint, where it diverges

abruptly to pass to its insertion. These tendons are often connected by accessory slips—*vincula*—above the knuckle-joints. They are subject to great variety, but they generally exist as strong slips extending from each side of the tendon of the ring finger to the adjacent tendon (Plate 49, Fig. 2, No. 8), so that this finger does not ordinarily admit of independent extension. The tendon of the index finger is usually free. On the back of each finger the common extensor tendon, after giving off the bands which serve as lateral ligaments to the metacarpo-phalangeal joint, is continued as the *digital aponeurosis*, into which the tendons of the corresponding lumbrical and interosseous muscles are inserted in relation to the second or medial phalanx (page 403), where the aponeurosis divides into three slips, the middle one of which is attached to the base of the medial phalanx, while the two lateral slips join in front of the latter and are inserted into the upper end of the third or ungual phalanx. This muscle is supplied by the posterior interosseous nerve. Not only is the function of this muscle to act as a general extensor of the fingers, but it can also act so as to extend the first phalanges while the second and third are flexed, and to extend the second and third phalanges while the first are flexed.

The *extensor minimi digiti muscle* arises from the external epicondyle and the adjacent intermuscular septa, and its fibres are arranged in a long slender bundle terminating in a tendon, which passes down the back of the forearm close to the tendons of the common extensor muscle, but occupying a separate compartment in the annular ligament, posterior to the inferior radio-ulnar joint. On the back of the hand the tendon divides into two slips which pass to the little finger, the slip on the radial side being joined by the tendon from the common extensor, already described, and then the tendons expand over the phalangeal joints and terminate in the same manner as the other extensor tendons of the fingers. It is supplied by the posterior interosseous nerve, and its special function is to extend the little finger independently.

The *extensor carpi ulnaris muscle* arises from the common tendon about the external epicondyle, from the septum between it and the preceding muscle, and from the posterior border of the ulna in immediate proximity to the origins of the flexor carpi ulnaris and flexor profundus digitorum

muscles. The fibres combine into a strong, broad tendon which is accommodated in a groove on the posterior surface of the ulna close to its styloid process, with which it is connected by a lateral expansion of fascia, and is finally inserted, after passing through a separate compartment in the posterior annular ligament, into the ulnar side of the base of the metacarpal bone of the little finger. There is also a fibrous expansion connecting its tendon with the extensor aponeurosis at the base of the little finger. The tendon is surrounded by an extension of the synovial membrane of the *wrist* as it lies in the groove on the ulna. When the forearm is in the position of full pronation, the end of the ulna can be *felt* and seen projecting between the tendons of the extensor carpi ulnaris and extensor minimi digiti muscles. There is usually a bursa placed beneath the tendon and the end of the bone. The posterior interosseous nerve supplies its proper nerve, and its function is to extend the hand toward the ulnar side.

The *anconeus muscle* is small, triangular, and placed at the external and posterior part of the elbow, arising by a tendon from the back of the external epicondyle and the contiguous portion of the capsule of the elbow-joint, from which diverging fibres pass to be inserted into the triangular surface on the upper fourth of the ulna. It is subcutaneous, and receives a special branch from the musculo-spiral nerve, which descends to it through the inner portion of the triceps muscle just above it. This muscle may be regarded as an extension of the triceps on to the forearm, which it assists in extending the elbow.

The *muscles of the deep layer of the posterior group of the forearm* are the supinator radii brevis, the three extensor muscles to the thumb, and the extensor indicis. The *supinator radii brevis muscle* arises beneath the mass of extensor muscles, from the lower and posterior part of the external epicondyle, from the external lateral ligament where it blends with the orbicular ligament, and from the roughened surface of the ulna below the lesser sigmoid cavity. The fibres of this muscle wind over the neck and upper part of the shaft of the radius and are inserted into the radius between the bicipital tubercle and the attachment of the pronator teres muscle. Occasionally there is a slip for this muscle attached specially

to the orbicular ligament. The supinator brevis is supplied by the posterior interosseous nerve (page 394), and acts as a powerful supinator of the radius.

The *extensor ossis metacarpi pollicis muscle* is situated immediately below the supinator brevis, and arises from the ulna below that muscle, from the interosseous ligament, and from the opposite surface of the radius. It descends obliquely, crossing over the radial carpal extensor muscles (Plate 49, Figs. 1, 2, and 3), about seven and a half centimetres, or three inches, above the wrist, passes through the annular ligament, and is inserted into the base of the metacarpal bone of the thumb, usually sending a slip to the trapezium. The *extensor primi internodii pollicis muscle* arises from the radius and the interosseous ligament just below the preceding muscle, which it accompanies through the annular ligament to be inserted into the base of the first phalanx of the thumb (Plate 49, Fig. 2, No. 14). This muscle is interesting as being peculiar to the human hand. The *extensor secundi internodii pollicis muscle* partially overlaps the preceding muscle, arising from the ulna below the extensor ossis metacarpi, from the interosseous ligament, and from the sheath of the *extensor minimi digiti muscle.* Its tendon passes independently through the annular ligament, in a distinct groove on the posterior surface of the radius, passes obliquely across the radial extensor tendons, and continues over the metacarpal bone and first phalanx of the thumb to be inserted into the base of the second or last phalanx (Plate 49, Fig. 1, No. 7). These tendons severally extend the portion of the thumb to which they are distributed. They can be readily distinguished through the skin, and the hollow produced by the extensor primi and extensor secundi tendons (the *tabatière anatomique*) is interesting because the radial artery here passes across its floor (Plate 49, Fig. 1, No. 17) to enter into the palm (page 414). The *extensor indicis muscle* arises from the posterior surface of the ulna, below the extensor secundi pollicis, and from the adjacent part of the interosseous ligament. Its tendon passes beneath the annular ligament in the same groove on the end of the radius with the tendon of the extensor communis muscle. It proceeds to the metacarpo-phalangeal joint of the index finger, where it is joined to the tendon from the common extensor (Plate 49, Fig. 1, No. 9).

This muscle is supplied by the posterior interosseous nerve, and its function is to enable the index finger to be extended independently.

The radial artery is the smaller of the two divisions of the brachial artery (page 354). It commences about opposite the head of the radius, and continues in the same line as the brachial artery as far as the wrist, being upon the radial side of the forearm, and for the most part between the supinator longus and flexor carpi radialis muscles. In the upper part of its course it is deeply situated between the pronator radii teres and the supinator longus, the fleshy border of the latter muscle usually overlapping it. This artery is superficial to the extent of eight centimetres, or a hand's breadth, above the wrist, and rests upon the lower part of the anterior surface of the shaft of the radius (Plate 46, Fig. 2, No. 16), so that it can be easily distinguished and compressed, and is therefore chiefly used as the most convenient vessel for examining the *arterial pulse.*

The *branches of the radial artery in the forearm* are the recurrent, superficialis volæ, muscular, and carpal. The *radial recurrent artery* is of variable size, arises below the elbow, and ascends between the supinator longus and brachialis anticus muscles, supplying in its course the two supinators and the two radial extensors (Plate 46, Fig. 1, No. 10). It inosculates with the superior profunda artery (page 354). The *arteria superficialis volæ* is variable both as to size and as to origin, and is sometimes absent. It usually arises from the radial artery near the wrist, where it turns to pass under the extensor muscles of the thumb. It runs over the anterior annular ligament (Plate 48, Fig. 2, No. 1) and above or through the muscles of the ball of the thumb, to anastomose generally with the superficial branch of the ulnar artery and establish the superficial palmar arch (Plate 48, Fig. 4, No. 4). There are nine or ten *muscular branches,* which furnish blood to the muscles on the radial border of the forearm. The *anterior* and *posterior carpal arteries* are small branches which usually leave the radial artery below the pronator quadratus and join the ramifications of the neighboring arteries in the *anterior* and *posterior rete carpi.*

The radial artery is accompanied by the *two deep radial veins,* or *venæ comites,* one on each side, which are connected by venous links extending

PLATE 52.

Figure 1.

The second phalangeal joint of the middle finger of the left hand laid open by an oval incision, as for the anterior flap of an amputation at this joint, to show the relations of the bone surfaces and the adjacent vessels.

1. The condyloid surface of the third or proximal phalanx of the middle finger.
2. The external lateral digital artery.
3. The glenoid surface of the head of the second phalanx of the middle finger.
4. The internal lateral digital artery.

Figure 2.

The metacarpo-phalangeal joint of the middle finger of the left hand opened, as in the first stage of an amputation (by the lateral-flap method) of the finger, to show the appearance of the ends of the bones at this joint. The position of the joint, on the dorsal surface, before the incisions were made, can be judged by comparison with the adjacent fingers.

1. The head of the metacarpal bone of the middle finger.
2. The external lateral digital artery.
3. The middle finger retained to show the character of the incisions for its removal by the lateral-flap method.
4. The trochlear surface of the third, or proximal, phalanx of the middle finger.
5. The internal lateral digital artery.

Figure 3.

Amputation at the carpo-metacarpal joint of the thumb of the left hand (by the flap method), showing the relative positions of the structures severed in the operation.

1. The radial artery where it passes into the palm.
2. The os trapezium.
3. The head of the metacarpal bone of the thumb drawn outward after division of the ligaments.
4. The thumb retained to show the proper character of the incisions in this amputation.
5. The external dorsal artery of the thumb.
6. The radialis indicis artery.
7. The princeps pollicis artery.
8. The internal dorsal artery of the thumb.

Figure 4.

The wrist-joint of the *right* hand laid open by an oval incision, as for the dorsal flap, in amputation at this joint, showing especially the appearance of the articulation between the lower end of the radius and the semilunar and scaphoid bones.

1. The lower end of the radius, showing the depression for the semilunar and scaphoid bones.
2. The triangular fibro-cartilage between the lower end of the ulna and the carpus.
3. The semilunar bone.
4. The cut tendons of the common extensor muscle to the fingers.
5. The divided radial artery.
6. The scaphoid bone.
7. The cut extensor tendons to the thumb.
8. The cut extensor tendon to the index finger.

Figure 5.

Vertical section through the articulations at the wrist of the *right* hand to show the synovial membranes and the cancellous structure and arrangement of the carpal bones.

1. The interosseous membrane.
2. Section through the lower end of the ulna.
3. The triangular inter-articular fibro-cartilage.
4. Section through the proximal row of the carpal bones.
5. Section through the distal row of the carpal bones.
6. Section through the heads of the metacarpal bones.
7. Section through the cuneiform bone.
8. Section through the pisiform bone.
9. Section through the unciform bone.
10. Section through the lower end of the radius.
11. Section through the semilunar bone.
12. Section through the scaphoid bone.
13. Section through the os magnum.
14. Section through the os trapezium.
15. Section through the trapezoid bone.
16. Section through the heads of the metacarpal bones.

Figure 6.

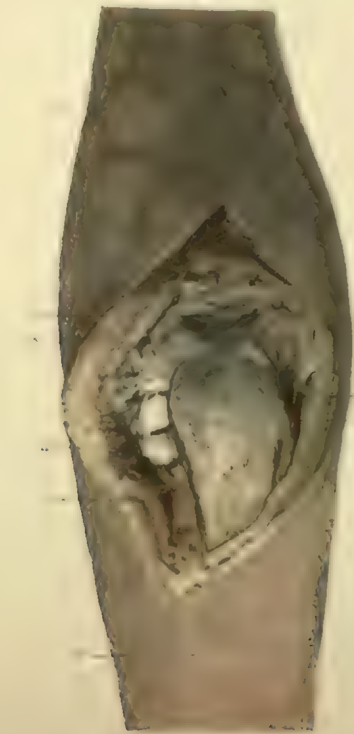
The left elbow-joint laid open posteriorly, as in the process of resection or excision of this articulation, to show the relations of the opposing bones and the adjacent structures.

1. The lower posterior portion of the left arm.
2. The severed tendon of the triceps muscle.
3. The trochlear surface of the lower end of the humerus.
4. The head of the radius.
5. Branch of the recurrent radial artery.
6. The upper portion of the left forearm.
7. The ulnar nerve.
8. The olecranon process of the ulna.
9. Branch of the recurrent ulnar artery.

Fig. 1

Fig. 2

Fig. 3



across the artery at frequent intervals, and join the venæ comites of the brachial artery in the ante-cubital fossa. The *radial nerve*, which is a branch of the musculo-spiral nerve (page 360), is in relation to the outer side of the radial artery in the middle third of the forearm only. About six centimetres, or two and a half inches, above the wrist the radial nerve passes under the tendon of the supinator longus muscle, to be distributed to the back of the hand (Plate 47, Fig. 1, No. 16).

Above the wrist, in the pulse-area, the radial vessels are often tortuous (Plate 46, Figs. 1 and 2). The *line of reference for the radial artery* may be drawn from the middle of the bend of the elbow to the ulnar side of the styloid process of the radius, or, for all practical purposes, an incision made parallel to the radial border of the forearm and two centimetres, or a finger's breadth, from it will expose the sheath of the radial vessels.

The ulnar artery is larger than the radial, with which it commences opposite the head of the radius at the bifurcation of the brachial artery. In the first part of its course it *curves* deeply beneath the pronator teres, the superficial flexor muscles, and the median nerve to the space between the flexor sublimis digitorum and flexor carpi ulnaris muscles, being overlapped by the tendon of the latter, and so completely ensheathed by a reflection of the deep fascia that its pulsation above the wrist can rarely be felt during life. Its course along the lower half of the forearm is more superficial and direct (Plate 46, Fig. 2).

The *branches of the ulnar artery in the forearm* are the anterior and posterior ulnar recurrent, articular, common interosseous, muscular, and carpal. The *anterior* and *posterior ulnar recurrent arteries* arise generally by a common trunk just after the origin of the main vessel at the elbow. The anterior passes upward to anastomose with the anastomotica magna and inferior profunda arteries. The posterior is the larger, and ascends between the two heads of the flexor carpi ulnaris muscle to the space between the olecranon and the internal epicondyle, by the side of the ulnar nerve, to communicate with the inferior profunda, anastomotica magna, and other arteries in the rete olecrani (page 370). The *articular branch* pierces the anterior part of the capsule of the elbow-joint at the

outer border of the brachialis anticus muscle. The *common interosseous artery,* which is four centimetres, or about one and a half inches, in length, arises from the ulnar artery, below the bicipital tubercle of the radius, and divides at the opening between the oblique and interosseous ligaments (page 375) into anterior and posterior branches. The *anterior interosseous artery* passes downward, being held in close contact with the interosseous ligament by a sheath of areolar tissue, as far as the upper border of the pronator quadratus muscle, where it subdivides into anterior and posterior branches, which join respectively the anterior and posterior *carpal rete.* The anterior interosseous artery in its course gives off the nutrient arteries to the radius and ulna, supplies the adjacent muscles with blood, and sends some perforating twigs through the interosseous membrane to the deep extensor muscles. It is provided with two *venæ comites* (Plate 46, Fig. 2, No. 14), and accompanied by a branch of the median nerve, the *interosseous nerve,* which overlies it superficially. The *posterior interosseous artery,* after reaching the posterior surface of the interosseous ligament, is in close relation with the posterior interosseous nerve (page 394). It gives off, besides muscular twigs to the superficial and deep extensor muscles, a *recurrent branch,* which joins the rete olecrani above, and finally ends below in the posterior carpal rete. The *muscular branches* of the ulnar artery are about a dozen in number, distributed to the contiguous muscles upon the ulnar side of the forearm. The anterior and posterior carpal branches arise from the ulnar artery above the wrist and join with the corresponding branches from the radial artery in forming the posterior carpal rete and the posterior palmar arch. The ulnar artery is also closely ensheathed with its two *venæ comites,* which are connected at intervals by venous links and empty into the venæ comites of the brachial artery below the elbow. The *ulnar nerve* takes a direct course along the ulnar side of the forearm, from the internal epicondyle to the radial side of the styloid process of the ulna, and therefore is at a considerable distance from the upper part of the ulnar artery, but for about six centimetres, or two and a half inches, above the wrist it is in close relation to the sheath of the vessels, the nerve being always to the ulnar side. Both vessels and nerve pass over the anterior an-

nular ligament together (Plate 48), and are held closely to the pisiform bone by an expansion of the fascia from the tendons of the flexor carpi ulnaris muscle. The *lines of reference for the ulnar artery* may be drawn from the tendon of the biceps at the front of the elbow to the middle of the ulnar side of the forearm, and thence straight to the radial side of the pisiform bone. Below the middle of the forearm the artery may be exposed by an incision made parallel to the ulnar border two centimetres, or a finger's breadth, from it. It should not be forgotten that the ulnar artery above the wrist is closely embraced by the border of the flexor carpi ulnaris muscle, and that therefore it is not so accessible or easy of exposure for a ligature as is the radial.

The *median nerve in the forearm* descends, after passing between the two heads of the pronator radii teres muscle below the flexure of the elbow (page 369), along the middle of the forearm, between the flexor sublimis and flexor profundus digitorum muscles. It is quite deep at first, but gradually becomes more superficial where the flexor muscles become tendinous, and at the wrist it passes beneath the anterior annular ligament between the outer tendon of the flexor sublimis and the inner border of the flexor carpi radialis muscle (Plate 46, Fig. 1, No. 16, and Plate 48, Fig. 3, No. 2). Near the elbow the median nerve sends, besides the two branches to the two heads of the pronator teres muscle, *muscular branches* to all the flexor muscles except the flexor carpi ulnaris and the ulnar part of the flexor profundus. The *anterior interosseous nerve* leaves the median just below the pronator teres muscle, and accompanies the anterior interosseous vessels (page 392), being on their radial side. It supplies the flexor longus pollicis, part of the flexor profundus, and the pronator quadratus muscles. There is also a *cutaneous palmar branch*, arising five centimetres, or two inches, above the wrist, which passes over the annular ligament and supplies the skin of the palm. Very often there is a branch from the median which joins the ulnar nerve where it is in more particular relation to the ulnar artery. The *ulnar nerve in the forearm*, as already stated (page 392), passes in a direct line from the front of the internal epicondyle to the radial side of the pisiform bone. At the elbow it gives off an *articular* branch to the elbow-joint, and soon after branches to both

of the heads of the flexor carpi ulnaris and the contiguous part of the flexor profundus muscle. About the lower third of the forearm the ulnar nerve distributes two branches, called from their distribution the *anterior* and *posterior ulnar cutaneous branches.* The *anterior* passes superficially over the ulnar artery to supply the skin of the front of the wrist, and the *posterior* passes beneath the tendon of the flexor carpi ulnaris to the *dorsal* surface. A few twigs from the ulnar nerve also supply the wrist-joint.

The *branches of the musculo-spiral nerve in the forearm,* besides the twigs supplied to the supinator longus and extensor carpi radialis longus muscles (page 360), which leave the nerve in the space between the brachialis anticus and the supinator longus in the outer depression of the elbow, are the posterior interosseous and the radial. The *posterior interosseous nerve* is the larger of the two terminal branches. It turns backward through the supinator brevis and passes downward between the superficial and deep extensor muscles to the middle of the posterior part of the forearm, curving thence under the extensor secundi internodii pollicis muscle to the back of the wrist. It supplies all the extensor muscles with which it is in relation throughout its course, and may be regarded exclusively as a motor nerve. The *radial nerve* is the cutaneous branch of the musculo-spiral in the forearm. Its course is along the middle of the forearm, under cover of the supinator longus muscle and to the outer side of the radial vessels. Above, in relation to the elbow, the nerve is placed considerably to the outer side of the artery; below, it passes beneath the tendon of the supinator longus muscle (Plate 47, Fig. 3, No. 8), pierces the deep fascia, and subdivides into two terminal branches, which are distributed to the skin on the back of the radial border of the hand (page 408), some of the filaments communicating with the terminal filaments of the musculo-cutaneous nerve.

Although *fractures of the bones of the forearm* are very common, it is surprising how little attention has been given to the anatomy of the parts involved, a knowledge of which would certainly influence the method of their treatment. These injuries may affect both the radius and the ulna, or either of these bones. When the two bones are broken, the violence

may be direct or indirect. When the radius is broken alone, it is generally due to indirect violence transmitted from the hand. When the ulna is broken alone, it is usually owing to direct violence and to its exposed position. Whatever shortening or displacement may occur in any form of these injuries is not so much in consequence of muscular action upon the fragments as on account of the direction from which the violence is received. The essential feature of the treatment of fractures of the forearm is the preservation of the normal dimension of the interosseous space, as already stated (page 376). This is generally appreciated nowadays; but it is of equal importance to remember that in all fractures, in whatever region they occur, the bones are not the only tissues which suffer from the injury. There is always accompanying the breach in the continuity of the bones more or less damage to the soft structures about them. The interosseous ligament and periosteum, with their special vessels, must be lacerated, and although in one sense this is essential for the process of repair, yet it presents a factor which probably accounts for the frequent unsatisfactory results of treatment. It should be borne in mind that the radius supports the hand, and that therefore it is most liable to suffer from non-union. The superficial veins (page 408) play a valuable part in nature's efforts at repair, and should not be interfered with. As soon as bony union has been obtained, passive motion should be resorted to at regular intervals.

The fracture at the lower end of the radius, known as *Colles's fracture*, usually occurs transversely from half an inch to one and a half inches above the wrist-joint. This is probably due to the character of the internal structure of the bone in this situation. The expanded lower end of the radius is mostly cancellous, while the shaft which joins it possesses a greater amount of compact tissue (Plate 52, Fig. 5). This fracture is usually caused by the weight being transmitted through the hand outstretched in the position of pronation to break the shock in the act of falling. The degree of displacement depends measurably upon whether the ligaments of the inferior radio-ulnar joint are ruptured.

The *development of the radius* occurs from three centres. The head is ossified in the fifth year, and joins the shaft about the eighteenth year.

The lower extremity is ossified during the second year, but does not unite with the shaft before the twentieth year. The *development of the ulna* also is from three centres, one for the shaft and one for each end. At birth the extremities are entirely cartilaginous. The olecranon does not begin to ossify until the tenth year, and it is joined to the shaft about the sixteenth year. The lower extremity ossifies in the fourth year, and joins the shaft in the twentieth year. It should be noted that the epiphyses which meet at the elbow unite with their shafts earlier than those at the opposite ends of the bones, also that the foramina of the medullary arteries are directed toward the elbow.

In *amputation through the middle of the forearm* by the antero-posterior oval-flap method, the parts exposed in the flaps when made upon the *left* side bear the following relations (Plate 51, Fig. 3). The anterior flap is composed chiefly of the flexor muscles, in the margin of which in the superficial fascia is the cut superficial median vein (No. 1). The median nerve (No. 3) is in the middle of the flap, between the severed superficial and deep flexor muscles. The ulnar vessels and the ulnar nerve (No. 5) are close to the sawn end of the ulna, and the radial vessel and the radial nerve are close to the sawn end of the radius. The interosseous vessels and nerve are between the bones. The posterior flap is composed chiefly of the extensor muscles, and in its margin will be found the superficial radial vein (No. 10).

THE REGION OF THE WRIST AND THE HAND.

The skeleton of the hand consists of the *carpus*, or wrist, which connects the hand with the forearm, the *metacarpus*, or median portion of the hand, and the *phalanges*, or digital extremities. The *carpal bones* are eight in number, polygonal in shape, and are composed of cancellous tissue enclosed in a compact layer. They are arranged in two rows, each of which contains four bones, counting from the external or radial side, as follows: in the upper or *proximal* row, the scaphoid, semilunar, cuneiform, and pisiform; in the lower or *distal* row, the trapezium, trapezoid, magnum, and unciform. Each of these little bones presents a dorsal surface which is usually comparatively smoother and larger than the

palmar surface, which is rough for the attachment of the ligaments, while the lateral borders are covered, in the recent state, with articular cartilage. When they are collectively united they form an arch with its concavity toward the palm, the scaphoid and the trapezium, the two outer bones of the two rows, and the pisiform and the unciform, the two inner bones of the two rows, projecting laterally. The contiguous surfaces of the carpal bones are so adapted that they form with one another gliding joints, the motion between any two of them being very slight, and limited to extension and flexion, with the exception of the os magnum, which appears to be also capable of a very little rotation. The articulation between the two rows, the *intercarpal joint*, however, admits of considerable motion, and materially contributes to the flexion and extension of the hand. The three principal bones of the upper row, the *scaphoid*, *semilunar*, and *cuneiform*, are connected by interosseous ligaments at their margins so that they present a convex surface which is received into the concavity formed by the *articular surface of the lower end of the radius and the under surface of the triangular fibro-cartilage*, thus establishing the important **radio-carpal** or **wrist joint** (Plate 52, Fig. 5).

The *triangular fibro-cartilage* separates the inferior radio-ulnar joint (page 375) from the wrist. It extends transversely beneath the lower end of the ulna, being attached by its apex to the groove between the styloid process and the head of the ulna, and by its base to the ridge between the ulnar depression and the articular surface of the lower extremity of the radius. Its lower surface is therefore really a continuation inward of the radial articular surface. The *synovial membrane* lining the cavity of the wrist-joint is separated from the synovial pouches between the carpal bones by the interposition of the interosseous ligaments, but there is very often a communication between the synovial cavities of the inferior radio-ulnar and radio-carpal joints through a deficiency in the triangular fibro-cartilage. The flexor and extensor tendons as they pass over this region afford strong protection to it, but beneath them there are fibrous bands which extend mostly from the margins of the radius and fibro-cartilage to the first row of carpal bones, and which with the intervening connective tissue constitute the *capsular ligament* of the wrist. The

various bands which have been specialized are the *anterior ligament* (or *ligamentum arcuatum*), composed mainly of intersecting fibres which pass obliquely from the anterior lip of the radius to the palmar surface of the scaphoid, semilunar, and cuneiform bones, a few fibres being inserted also into the os magnum. This is reinforced by an additional band placed more superficially, extending from the base of the styloid process of the ulna to the cuneiform bone, and attached to the fibro-cartilage between them; the *external lateral ligament*, which is short and thick and extends from the styloid process of the radius to the outer side of the scaphoid; the *posterior ligament* (or *ligamentum rectum*), consisting of intersecting fibres which pass from the posterior margin of the radius and the fibro-cartilage to the dorsal surface of the semilunar and cuneiform bones; and the *internal lateral ligament*, which is a round band, longer and narrower than the external, and extends from the tip of the styloid process of the ulna to the cuneiform bone.

The movements permitted at the wrist-joint are flexion, extension, abduction, adduction, and circumduction, but not rotation. This joint acts harmoniously with the intercarpal and carpo-metacarpal joints, all of them being closely associated, so that they move simultaneously. The radio-carpal joint is supplied by filaments from the ulnar and posterior interosseous nerves. In opening the wrist-joint from the dorsal surface, as in amputation (Plate 52, Fig. 4), the peculiar convex arrangement of the upper row of carpal bones and the cup-shaped concave surface formed by the lower end of the radius and triangular cartilage present themselves, together with several bands of the capsule which project across the cavity of the joint and about which the synovial membrane is gathered into folds.

The pisiform bone articulates with the cuneiform bone, and the joint thus formed is surrounded by a capsular ligament and provided with a distinct *synovial membrane*. It is also strongly connected by ligamentous fibres with the unciform and fifth metacarpal bones. It serves mainly to give attachment to the flexor carpi ulnaris and abductor minimi digiti muscles. Besides the synovial membranes peculiar to the inferior radio-ulnar joint, to the radio-carpal or wrist joint, and to the piso-cuneiform joint, just described, there are two distinct synovial membranes, enclosed

within the articulations formed by the carpal bones in relation to one another (the intercarpal joint) and to the bases of the metacarpal bones. The largest of these extends between both rows of the carpal bones, sending short pouches upward between the bones of the first row, and longer pouches downward between the bones of the second row, which are expanded between the latter and the bases of the contiguous metacarpal bones. The smaller synovial membrane is interposed between the trapezium and the metacarpal bone of the thumb. It is not uncommon to find that the interosseous ligament between the magnum and unciform bones is attached to the ridge on the fourth metacarpal bone, and consequently there is a subdivision of the larger synovial membrane between the unciform and the bases of the fourth and fifth metacarpal bones. The carpal bones are all connected by interosseous ligaments at their dorsal and palmar margins, of variable development, which blend with the especial *ligaments of the intercarpal joint*, and are called, from their positions, the *palmar* and *dorsal ligaments*. The palmar consists of strong fibres which radiate from the tuberosity of the os magnum to all the adjacent bones, and therefore is sometimes known as the *ligamentum radiatum*. The dorsal is somewhat weaker, and consists mostly of transverse fibres which extend from the back of the os magnum over the other bones and unite with the dorsal ligaments of the radio-carpal joint above and the carpo-metacarpal joints below.

The metacarpal bones, five in number, are modified long bones, each consisting of a somewhat triangular shaft, slightly bowed, with the concavity toward the palm. The proximal ends, or bases, are irregular, presenting tuberosities for the attachment of the ligaments and smooth facets for articulation with the carpal bones and the adjoining metacarpal bones, with which they are in relation. The distal ends, or *heads*, are quadrate, and provided with lateral depressions for ligaments, and spheroidal eminences for reception upon the glenoid surfaces of the proximal ends of the first phalanges. The articular processes of the heads embrace more of the palmar than of the dorsal surfaces. The metacarpal bones of the fingers are proportionately more slender than the metacarpal bone of the thumb, which is shorter and broader. They all diverge slightly

PLATE 53.

Figure 1.

Topographical survey of the right side of the head, face, and neck, with especial adaptation to cranio-cerebral study. the localization of the areas of distribution of the sensory nerves, and spots where electrical stimulation produces reflex contractions of some of the muscles in these regions. Also the landmarks for the operations of tracheotomy and of laryngotomy.

1. Cutaneous area of supra-orbital nerve.
2. Position of superior frontal fissure.
3. Cutaneous area of auriculo-temporal nerve.
4. Position of the fissure of Rolando.
5. Position of horizontal branch of the fissure of Sylvius.
6. Spot where reflex contraction of the temporal muscle may be produced.
7. Cutaneous area of occipitalis major nerve.
8. Cutaneous area of occipitalis minor nerve.
9. Spot where reflex contraction of the splenius muscle may be produced.
10. Spot where reflex contraction of the trapezius muscle may be produced.
11. Posterior cervical folds of the integument produced by contraction of the trapezius muscle.
12. Spot indicating position of the brachial plexus of nerves.
13. Cutaneous area of supra-trochlear nerve.
14. Position of inferior frontal fissure.
15. Cutaneous area of infra-trochlear nerve.
16. Cutaneous area of lachrymal nerve.
17. Cutaneous area of nasal nerve.
18. Position of ascending branch of the fissure of Sylvius.
19. Cutaneous area of infra-orbital nerve.
20. Cutaneous area of temporo-malar branch of the superior maxillary nerve.
21. Spot where reflex contraction of the masseter muscle may be produced.
22. Cutaneous area of buccal nerve.
23. Cutaneous area of mental nerve.
24. Position where facial artery and vein pass over the body of the jaw in front of masseter muscle.
25. Spot where reflex contraction of the sterno-cleido-mastoid muscle may be produced.
26. Position of body of the hyoid bone.
27. Cutaneous area of auricularis magnus nerve.
28. Anterior prominence of the thyroid cartilage.
29. Point where the common carotid artery is in relation to the transverse process of the fourth cervical vertebra.
30. Position of the hoop of the cricoid cartilage.
31. Spot where reflex contraction of the omo-hyoid muscle may be produced.
32. Supra-sternal notch.

Figure 2.

The left hand in the position of pronation, showing a topographical survey of the areas of distribution of the sensory nerves on the back of the hand and fingers, and spots where electrical stimulation produces reflex contraction of some of the muscles.

1. Area supplied by the median nerve on ulnar side of dorsal surface over third phalanx of middle finger.
2. Lowest distribution of ulnar nerve on ulnar side of middle finger.
3. Area supplied by median nerve on dorsal surface of radial side over third phalanx of ring finger.
4. Lowest distribution of ulnar nerve on ulnar side of dorsal surface of ring finger.
5. Ulnar nerve on radial side of little finger.
6. Ulnar nerve on ulnar side of little finger.
7. Spot where contraction of the third dorsal interosseous muscle may be produced.
8. Spot where contraction of the fourth dorsal interosseous muscle may be produced.
9. Spot where reflex contraction of the abductor minimi digiti muscle may be produced.
10. Ulnar nerve on back of wrist.
11. Median nerve on dorsal surface of third phalanx of middle finger.
12. Lowest distribution of radial nerve on radial side of middle finger.
13. Median nerve on dorsal surface of ulnar side of third phalanx of index finger.
14. Lowest distribution of radial nerve on ulnar side of index finger.
15. Median nerve on radial side of dorsal surface of third phalanx of index finger.
16. Lowest distribution of radial nerve on radial side of index finger.
17. Radial nerve on dorsal surface of thumb.
18. Spot where contraction of second dorsal interosseous muscle may be produced.
19. Spot where contraction of first dorsal interosseous muscle may be produced.
20. Radial nerve on dorsal surface of wrist.
21. Lowest distribution of musculo-spiral nerve.

Figure 3.

The right hand in the position of supination, showing a topographical survey of the areas of distribution of the sensory nerves on the palm of the hand and anterior surface of the fingers, and spots where some of the muscles may be caused to contract by electrical stimulation. Also the surface-markings on the palm of the hand in relation to the arterial arches.

1. Median nerve on ulnar side of palmar surface of middle finger.
2. Median nerve on radial side of palmar surface of ring finger.
3. Ulnar nerve on ulnar side of palmar surface of ring finger.
4. Ulnar nerve on palmar surface of radial side of little finger.
5. Ulnar nerve on palmar surface of ulnar side of little finger.
6. *Linea mensalis.*
7. Spot where contraction of the third lumbrical muscle may be produced.
8. Spot where contraction of the fourth lumbrical muscle may be produced.
9. *Linea hepatica.*
10. *Linea cephalica.*
11. Spot where contraction of the opponens minimi digiti muscle may be produced.
12. Spot where contraction of the abductor minimi digiti muscle may be produced.
13. Spot where contraction of the opponens pollicis muscle may be produced.
14. Spot where contraction of the palmaris brevis muscle may be produced.
15. Ulnar nerve on front of wrist.
16. Median nerve on palmar surface of radial side of middle finger.
17. Median nerve on palmar surface of ulnar side of index finger.
18. Median nerve on palmar surface of radial side of index finger.
19. Spot where contraction of the second lumbrical muscle may be produced.
20. Spot where contraction of first lumbrical muscle may be produced.
21. Spot where contraction of the adductor pollicis muscle may be produced.
22. Internal branch of median nerve on palmar surface of thumb.
23. External branch of median nerve on palmar surface of thumb.
24. Spot where contraction of the flexor brevis pollicis muscle may be produced.
25. *Linea vitalis.*
26. Spot where contraction of the abductor pollicis muscle may be produced.
27. Median nerve below the wrist.
28. *Linea transversa carpi.*
29. Median nerve above the wrist.
30. Spot where contraction of the flexor longus pollicis muscle may be produced.
31. Spot where contraction of the tendons of index and little fingers may be produced.
32. Spot where contraction of the tendons of middle and ring fingers may be produced.

Fig. 1

Fig. 2

Fig. 3

...graphed and Designed from Nature by George McClellan M.D.

from the carpus, but that of the thumb diverges more than the others. The metacarpal bone of the index finger is the longest of the series, the rest of which are successively shorter toward the little finger, its metacarpal bone being longer than that of the thumb. The latter is peculiar in having its palmar surface turned toward the ulnar side of the hand; its base has no lateral facet, being provided with an oval facet for articulation with the trapezium only. The head is less pronounced than in the corresponding bones, and has two marked processes on the palmar surface for the two sesamoid bones (page 402). The joint between the trapezium and the metacarpal bone of the thumb is distinct and protected by a capsular ligament, which is particularly strong in the external and dorsal portions. The proximal ends of the metacarpal bones are connected by *interosseous ligaments,* and each carpo-metacarpal joint is provided with palmar, dorsal, and lateral ligaments.

The phalanges are fourteen in number,—three in each finger and two in the thumb. They are designated as the first or proximal, the second or medial, and the third or distal. The latter are also called the ungual phalanges, because they support the nails. The phalanges in each of the digital extremities successively decrease in size toward the wrist. They are all long bones with semi-cylindrical shafts. The dorsal surfaces of the first and second phalanges are slightly convex, except that of the thumb, which is rather concave and tapers toward the distal end. The upper ends of the first phalanges are severally provided with glenoid depressions variably modified for articulation with the metacarpal bones to which they belong, and their lower ends present trochlear surfaces for articulation with their proper second phalanges. The upper ends of the latter have each a double concavity for the reception of the trochlear surfaces of the first phalanges, and their lower ends are also provided with similar trochlear surfaces, but smaller than those of the first phalanges. The second phalanges of the middle and ring fingers are about equal in length, that of the index finger is shorter, and that of the little finger is the smallest of the series.

The *third* or *ungual phalanges* are all provided with concavities at their upper ends, each presenting two depressions, for articulation with the

second phalanges, and they terminate in the horseshoe-shaped *ungual processes,* which are roughened on their palmar surfaces for the attachment of the pulps of the fingers. The ungual process of the thumb is the largest and broadest, while the ungual processes of the middle, ring, index, and little fingers follow in order as named.

The *metacarpo-phalangeal joints* are enarthrodial, being capable of extension, flexion, abduction, adduction, and slight rotation. The contiguous bony surfaces are each provided with a layer of articular cartilage and a synovial membrane, the glenoid depressions on the proximal ends of the first phalanges being deepened by small *glenoid ligaments.* These joints are surrounded by *capsular ligaments,* which being comparatively weak in their dorsal portions are strengthened by expansions from the extensor tendons (Plate 49). The fibres at each side are very strong, and have been specialized as *lateral ligaments.*

The *second* and *third interphalangeal joints* are ginglymoid, being capable only of flexion and extension. They are constructed similarly to the metacarpo-phalangeal joints, having *glenoid* and *capsular ligaments,* the side bands of the latter being strengthened into *lateral ligaments.* At the metacarpo-phalangeal joint of the thumb there are always found two *sesamoid bones,* the outer being the larger. They are the ossified nodules of fibro-cartilage, in relation to the lateral ligaments, and receive the insertions of short muscles.

The spaces between the metacarpal bones are occupied by the *interosseous muscles,* which are arranged in two sets, *palmar* and *dorsal.* There are three palmar interosseous muscles, each of which has a single origin. The *first* arises from the base and front of the metacarpal bone of the index finger, and is inserted into the ulnar side of the dorsal aponeurosis of the three phalanges belonging to the digital extremity of that finger. The *second* arises from the metacarpal bone of the ring finger, and is inserted into the radial side of the dorsal aponeurosis of the corresponding phalanges. The *third* arises from the metacarpal bone of the little finger, and is inserted into the radial side of its phalanges. There are four dorsal interosseous muscles, each of which has two origins. The *first* arises from the ulnar side of the upper portion of the metacarpal bone

of the thumb and the whole of the adjacent side of the metacarpal bone of the index finger, and is inserted into the radial side of the base of the proximal phalanx and the dorsal aponeurosis over the medial and distal phalanges of that finger. The *second* arises from the adjacent sides of the metacarpal bones of the index and middle fingers, and is inserted into the radial side of the aponeurosis enveloping the phalanges of the middle finger (Plate 49, Fig. 1, No. 19). The *third* arises from the adjacent sides of the metacarpal bones of the middle and ring fingers, and is inserted into the ulnar side of the aponeurosis over the phalanges of the middle finger. The *fourth* arises from the adjacent sides of the metacarpal bones of the ring and little fingers, and is inserted into the ulnar side of the aponeurosis over the phalanges of the ring finger. The general function of the palmar set is to adduct the fingers toward the middle line of the middle finger, while that of the dorsal set is to abduct the fingers from that line.

The *dorsal aponeurosis* of the fingers, above mentioned, is formed by the expansion of the extensor tendons (Plate 49) after they have given off the flat bands to the sides of the metacarpo-phalangeal joints. It is continued down the fingers, being attached by a middle slip to the bases of the medial phalanges, and by lateral slips which intersect and are inserted into the bases of the ungual phalanges (page 402). On the sides of the proximal phalanges the aponeurosis receives the insertions of the interosseous muscles, described above, as well as those of the *lumbricales muscles.* The latter are four slender bundles of muscular fibres which arise from the deep flexor tendons in the palm of the hand. The *first* and *second* are attached to the radial sides of the tendons of the index and middle fingers, and are inserted into the radial sides of the digital aponeuroses below. The *third* and *fourth* arise from the contiguous surfaces of the adjacent tendons of the ring and little fingers, and are inserted into the radial sides of their digital aponeuroses. The first and second lumbricales are supplied by the median nerve, the third and fourth by the ulnar nerve. Their function is to flex the metacarpo-phalangeal joints, but they can also assist the action of the extensor tendons in maintaining the extension of the interphalangeal joints. It has already been stated

that all the flexor tendons become enclosed in aponeurotic sheaths opposite the palmar surface of the metacarpo-phalangeal joints, and that as they enter these sheaths the superficial tendons divide into lateral slips, which diverge about the middle of the proximal phalanges, to allow the deep flexor tendons to pass between them. The two lateral slips of the superficial tendons blend together behind the deep tendons, and then separate again, to be finally inserted into the sides of the medial phalanges, while the deep tendons are continued on, to be inserted into the bases of the ungual phalanges. In this connection it should be noted that the metacarpo-phalangeal joints are capable of being flexed so that the fingers may be brought into the hollow of the palm, thus forming the *fist*, while the heads of the metacarpal bones and the bases of the proximal phalanges are made prominent at the *knuckles*. The fingers can be extended only very little beyond the plane of the metacarpus, but they can be readily moved laterally. The interphalangeal joints can be flexed or extended so that the separate phalanges shall move in the same manner as the entire fingers, but they have no lateral movement.

The construction of the joint of the *thumb*, between its metacarpal bone and the trapezium, enables it to be opposed to all the fingers. The special flexor (page 383) and extensor (page 388) muscles of the thumb have already been described. Besides these there are the muscles which constitute the *ball of the thumb*.

The *abductor pollicis muscle* (Plate 48, Fig. 3, No. 3) arises from the anterior annular ligament and the tubercle of the trapezium, and is inserted into the outer side of the proximal phalanx of the thumb. This muscle is supplied by a branch of the median nerve, and often consists of two slips, between which passes the superficialis volæ artery (page 389). The action of this muscle is to draw the thumb away from the rest of the hand.

The *opponens pollicis muscle* (Plate 48, Fig. 4, No. 2) arises beneath the abductor, also from the annular ligament and the trapezium, and is inserted into the metacarpal bone of the thumb upon the whole length of its radial border. It is supplied by a branch of the median nerve. By its action the thumb is brought forcibly in apposition with all the fingers.

The *flexor brevis pollicis muscle* has a double origin, a superficiai portion

arising from the trapezium and annular ligament, which is inserted into the outer sesamoid bone and the radial surface of the proximal phalanx of the thumb, and a deeper portion which arises from the bases of the metacarpal bones of the index and middle fingers and the fibrous arch between them and the trapezoid and magnum and is inserted into the inner sesamoid bone and the base of the proximal phalanx of the thumb. The superficial portion is supplied by the median nerve, the deep portion by the ulnar nerve. The tendon of the *long* flexor muscle passes between these two portions, to be inserted into the base of the ungual phalanx of the thumb (page 383). The function of the flexor brevis is to flex the proximal phalanx of the thumb upon the palm.

The *adductor pollicis muscle* (Plate 48, Fig. 4, No. 7) is triangular, and arises from the shaft of the metacarpal bone of the middle finger, its fibres blending with those of the deep portion of the flexor brevis, to be inserted into the inner sesamoid bone and the adjoining part of the proximal phalanx of the thumb. Sometimes two portions of this muscle are differentiated as the *oblique* and *transverse adductors*, but they are very imperfectly separable. The adductor pollicis is supplied by the ulnar nerve. Its action is to augment that of the flexor brevis, and to enable the tip of the thumb to be brought into contact with the tips of the fingers. The mobility of the thumb and the power which it possesses through its many muscles render it one of the distinguishing features of the human hand.

The *muscles of the ball of the little finger* resemble somewhat those of the thumb. The *abductor minimi digiti muscle* (Plate 48, Fig. 2, No. 13) arises from the pisiform bone and its capsular ligament and is inserted into the ulnar side of the base of the proximal phalanx of the little finger, blending with its dorsal aponeurosis. It sometimes receives an accessory slip from the tendon of the flexor carpi ulnaris. The *flexor brevis minimi digiti muscle* (Plate 48, Fig. 4, No. 17) is really a part of the abductor. It arises from the unciform process, and is inserted also into the base of the proximal phalanx of the little finger and into the adjacent aponeurotic arch over the deep flexor tendon. The action of the abductor muscle is to draw the little finger away from the rest of the hand, and it is

assisted in this effort by the flexor brevis. The *opponens minimi digiti muscle* arises beneath the flexor brevis from the unciform process and the under surface of the annular ligament, and is inserted on the ulnar side of the metacarpal bone of the little finger. The action of this muscle is to draw the metacarpal bone of the little finger upon the palm, so as to strengthen its power of grasping. All these muscles of the little finger are supplied with branches from the ulnar nerve.

The *surface-markings of the wrist and hand* are of considerable topographical importance. The positions of all the bony prominences in this region should be noticed, in extension and flexion, as well as in supination and pronation. The lower extremities of the radius and ulna can be readily defined, because they are to a great extent superficial. It has already been stated that the laxity of the capsular ligament about the inferior radio-ulnar joint permits of slight lateral motion between the bones of this articulation when the radius is rotated, and consequently it is the styloid process of the ulna which is felt in supination, and not the head of that bone. The styloid process of the radius is placed more anteriorly than the corresponding process of the ulna, and is also twelve millimetres, or half an inch, lower. Below and in front of the radial styloid process the tubercle of the scaphoid bone can be felt, and below and in front of the ulnar styloid process is the pisiform bone. A line drawn from one styloid process to the other will be found to pass downward and outward, and its extremities represent the lower limits of the radio-carpal joint, the line of the joint itself being in the form of an arc with the convexity upward (Plate 52, Fig. 4).

The *skin* over the wrist is quite loose, thin, and free from fat. In front of the wrist the skin is closely connected with the deep fascia, and is marked by *transverse lines*, of which the *lowest* is usually very distinct (Plate 53, Fig. 3, No. 28). It is about one and a half centimetres, or three-quarters of an inch, below the wrist-joint, and crosses the os magnum in the line of the metacarpal bone of the middle finger. This line also corresponds to the upper border of the anterior annular ligament (page 412). About the middle of the anterior surface of the wrist the tendon of the palmaris longus muscle is usually plainly seen, especially when

the wrist is flexed with the fingers extended. The flexor carpi radialis tendon is on its outer side. The median nerve as it descends from the forearm to enter the palm beneath the annular ligament is between these two tendons (Plate 48, Fig. 4, No. 1). The tendon of the flexor carpi ulnaris muscle can be easily distinguished as it passes to the pisiform bone on the inner side of the wrist, when that joint is slightly flexed and the little finger closed upon the palm. The tendons of the flexor sublimis digitorum muscle are in the depression between the tendons of the flexor carpi ulnaris and the palmaris longus. Within the superficial fascia on the palmar surface of the thumb and the front of the wrist the *superficial veins* can be seen through the thin skin passing upward from the palmar plexus to empty into the median and ulnar veins. On the radial border of the wrist the tendons of the extensor ossis metacarpi and primi internodii pollicis muscles are brought into distinct relief when the thumb is abducted; and on the back of the wrist the tendon of the extensor secundi internodii pollicis muscle is rendered prominent when the thumb is forcibly extended and abducted. The extensor carpi ulnaris tendon can be felt upon the inner side of the posterior surface of the wrist, and to the radial side of it are the tendons of the extensor communis digitorum.

If the skin is removed from the back of the hand, the above tendons will be seen as they pass beneath the *posterior annular ligament* (Plate 49, Fig. 3, No. 7). This consists of a special condensation of the deep fascia in this locality, which is formed by the transverse fibres of the deep fascia prolonged from the forearm and augmented by special fibres which are attached to the ridges on the back of the lower end of the radius and thence pass obliquely inward over the capsular ligament of the inferior radio-ulnar joint to the ulnar side of the carpus, where they are attached to the pisiform and cuneiform bones. The several attachments of the deep fibres to the ridges on the radius convert the grooves into canals for the passage of the extensor tendons. There are *six* compartments thus formed in the posterior annular ligament, as follows: one for the extensor ossis metacarpi and the extensor primi internodii pollicis; one for the extensor radialis longior and the extensor radialis brevior; one for the extensor secundi internodii pollicis; one for the extensor indicis and the extensor

communis digitorum; one for the extensor minimi digiti; and one for the extensor carpi ulnaris. All these compartments are lined by *synovial membranes* which envelop the tendons and accompany them nearly as far as their insertions. Sometimes there is a communication between one of the above synovial sheaths and the cavity of the wrist-joint.

The *skin over the back of the hand* is very fine, and but loosely attached to the annular ligament enclosing the tendons and to the deep fascia prolonged from it to the knuckles below, owing to the extreme laxity of the subcutaneous tissue. This is manifest in œdema and extravasations which often occur here. The skin is also provided with numerous short fine hairs and sebaceous follicles. The hairs are so set that they have an inclination toward the ulnar border, and they are extended also over the dorsal surfaces of the first and second phalanges of all the fingers. The sweat-glands are not so numerous on the back of the hand as they are on the *palm*, where they are remarkable for the profuseness of their perspiration under certain conditions. The skin of the back of the hand is not very sensitive to tactile impressions.

The *superficial veins of the hand* (Plate 47, Fig. 3) arise mainly from the *dorsal plexuses*, which commence by radicles forming arches over the backs of the proximal phalanges. On the ulnar side the *ulnar dorsal plexus* is formed by the union of the vein from the little finger (the *vena salvatella*) with the veins from the third and fourth interdigital clefts. From this plexus usually two veins ascend to the forearm, a *small anterior superficial ulnar* and a *larger posterior superficial ulnar*. On the radial side the *radial dorsal plexus* is formed by the junction of the vein from the thumb (the *vena cephalica pollicis*) with veins from the index and middle fingers, which terminate in the radial veins above. There is much diversity in the arrangement of these veins on the back of the hand, and the two plexuses are frequently connected by a transverse venous link, which presents an H-shaped appearance.

As the vein from the thumb passes upward it crosses the *hollow* formed by the extensor tendons of the thumb, and in close relation with it are the branches of the *radial nerve* (Plate 47, Fig. 3, No. 9) which pass to supply the dorsal surface of the thumb and the dorsal surface of the index and

the radial side of the middle finger as far as their distal phalanges (Plate 53, Fig. 2). At the bottom of the hollow, beneath the tendons, the *radial artery*, in a bed of fat which separates it from the scaphoid and trapezium, passes (Plate 49, Fig. 1, No. 17) to the interval between the first and second metacarpal bones to enter the palm between the two portions of the abductor indicis muscle and form the deep palmar arch (page 415). Before leaving the back of the hand the radial artery gives off the *posterior carpal artery*, which passes beneath the extensor tendons, forming an arch with the corresponding branch from the ulnar artery. From this dorsal arch the *dorsal interosseous arteries* arise (Plate 47, Fig. 3, and Plate 49, Fig. 3). They descend to the muscles occupying the several interosseous spaces, supplying them and the other adjacent parts, and inosculating near the metacarpo-phalangeal joints with the perforating branches from the deep palmar arch. On the ulnar side of the back of the hand the *ulnar nerve* appears just below the styloid process of the ulna, and in relation to the vein from the little finger (Plate 47, Fig. 3, No. 5) it divides into branches which supply the dorsal surface of the little finger, the whole of the dorsal surface of the ring finger, except the radial border of the distal phalanx, and the dorsal surface of the ulnar side of the middle finger, except over the distal phalanx (Plate 53, Fig. 2, No. 10).

The palm of the hand presents some conspicuous features which should be closely examined. There is a large prominence on the radial side, formed by the muscles of the ball of the thumb, already described (page 404), which is called the *thenar eminence;* while upon the ulnar side the long prominence corresponding to the muscles of the ball of the little finger is the *hypothenar eminence.* The two eminences are sometimes named the *heel of the hand.* Between them, over the annular ligament, there is a depression, which broadens toward the fingers, and when the latter are flexed forms the *hollow of the hand.* The skin of the palm is attached to the fascia beneath along the many lines of flexion, three of which are especially marked and have been designated as follows. The *first* line, curving round the base of the thenar eminence, is caused by the constant flexion of the thumb, and is called the *linea vitalis* (Plate 53,

Fig. 3, No. 25). It corresponds to the attachment of the radial margin of the palmar fascia. The *second* line commences at the radial side of the hand, between the index finger and the thumb, and extends across the palm to about the middle of the metacarpal bone of the little finger, is caused by the apposition of the middle and index fingers with the thumb, and is known as the *linea cephalica.* This line indicates the position of the metacarpo-phalangeal joint of the index finger, and is a useful guide in its amputation. The *third* line, which is the lowest upon the extended palm, commences at the elevation between the index and middle fingers and runs obliquely to the ulnar border of the hand, is caused by the flexion of the middle, ring, and little fingers, and is known as the *linea mensalis.* The last two lines are intersected by another, less conspicuous, which takes a vertical course nearly over the metacarpal bone of the middle finger, is called the *linea hepatica,* and gives to these markings the characteristic outline of the letter **M** (Plate 53, Fig. 3). The second line where it crosses the metacarpal bone of the ring finger is about over the lowest part of the superficial palmar arch (page 414). The third line is the most important. It is one centimetre, or a little less than half an inch, above the metacarpo-phalangeal joints of the fingers which produce it, and indicates very nearly the upper limits of the synovial sheaths of the index, middle, and ring fingers. Just beyond this line the palmar fascia divides into its four slips (page 412). The position of the metacarpo-phalangeal joints can be ascertained by alternate flexion and extension, and will be found to be for each finger at a point midway between the third palmar line and the webs of the fingers. The same points refer to the bifurcation of the digital arteries (Plate 48, Fig. 4). When the proximal phalanges are extended and the medial and distal are flexed, three little elevations are noticed, formed by the pressing forward of the little cushions of fatty tissue which occupy the arches made by the digital slips of the palmar fascia over the flexor tendons. The palmar surface is further marked at the bases of the fingers by transverse flexion-folds, which are single for the index and little fingers and double for the middle and ring fingers. These folds are about two centimetres, or three-quarters of an inch, below the corresponding metacarpo-phalangeal joints. There

are similar folds produced by the flexion of the interphalangeal joints, the first of which is double and the second usually single for each finger. They do not correspond to the joints, being usually from three to one and a half millimetres, or from one-eighth to one-sixteenth of an inch, above them. The thumb is provided with two folds corresponding to its two joints, the upper one of which passes obliquely over the metacarpo-phalangeal joint. The free margin of the web between the fingers is called the *plica interdigitalis*, and is about two centimetres, or three-quarters of an inch, from the metacarpo-phalangeal joints on the palmar surface. These measurements are exact, but it is always best for practical purposes to remember the unfailing rule of exercising the functions of these joints when in doubt, which will demonstrate their position and features better than any description. The palmar epidermis varies in thickness mainly according to the uses to which the hands are put. There are abundant sweat-glands, as already stated. The papillæ are exceedingly large and numerous, and contain touch-corpuscles. On the rounded *pulps* of the fingers they are arranged in irregular concentric ridges, never being precisely alike in any two hands.

The *subcutaneous tissue of the palm* is scanty, and resembles the same tissue in the scalp, as mentioned in the description of that structure, as it is intimately associated with the palmar fascia beneath. Owing to the denseness of this tissue and the thickness of the cuticle, the hand is peculiarly adapted to sustain the effects of pressure and friction. The ulnar border of the palmar part of the hand is remarkably well provided in this respect and protected by the soft parts, without the presence of any large nerves. The *palmaris brevis muscle* consists of short transverse fibres arising from the skin over the hypothenar eminence and attached to the palmar fascia. Its contraction assists in grasping. When the skin of the palm with the above muscle is carefully removed, the palmar fascia and the anterior annular ligament are exposed.

The palmar fascia is a strong, silvery-white, glistening tissue spread over the centre of the palm, and when completely developed is really the expansion of the tendon of the palmaris longus muscle (Plate 48, Fig. 1, No. 8). In such cases it overlies the annular ligament proper; but very

often it appears to be simply a downward prolongation from that ligament over the palm, the tendon of the palmaris longus losing itself in the upper margin of the ligament. The palmar fascia consists chiefly of strong longitudinal fibres, which constitute the outer or superficial layer, and can be separated by careful dissection (Plate 48, Fig. 2, No. 8) from a deep layer of transverse fibres which are in immediate relation with the lower border of the annular ligament. At the borders of the thenar and hypothenar eminences the palmar fascia becomes thinner, and a layer composed of the deeper transverse fibres passes over the muscles forming these eminences to blend with the dorsal fascia. Toward the fingers the fascia divides into four slips, which are inserted chiefly into the bases of the proximal phalanges and the anterior surfaces of the capsular ligaments of the metacarpo-phalangeal joints, while some of the deeper fibres form lateral slips which blend with the aponeurotic sheaths of the flexor tendons, and others pass round and join the dorsal aponeurosis over the extensor tendons. In the arches formed by the attachment of the slips there are little cushions of fatty tissue which enclose the digital nerves and arteries and the tendons of the lumbricales muscles as they pass to the fingers. Many of the fibres of the superficial layer of the fascia are associated with the skin, which renders its dissection from the fascia very tedious. From the deeper layer there are two weak slips which pass across to be attached to the lateral expansions enclosing the muscles of the thenar and hypothenar eminences. The one to the thumb is especially noticeable (Plate 48, Fig. 1, No. 4). From the under surface septa also pass to the metacarpal bones. Beneath the skin of the webs of the fingers there are transverse fibres, called the *superficial transverse ligaments*, which cross over the vessels and nerves and afford them greater protection from pressure when the hand is used in grasping. The palmar fascia, like all the expansions of the deep fascia, is subject to great variability, depending upon development. In the hands of mechanics it is always very strong, and among persons who habitually use their fingers requiring effort doubtless many accessory slips are produced. The ulnar artery and ulnar nerve descend to the palm over the annular ligament and between the two layers of the palmar fascia (Plate 48, Fig. 2, Nos. 11 and 12).

The anterior annular ligament consists of a strong transverse band of fibrous tissue arching across from the unciform process and the pisiform bone to the trapezium and the tuberosity of the scaphoid bone. It is continuous with the deep fascia of the forearm above and with the deep layer of the palmar fascia below. Most of the muscles of the ball of the thumb and of the little finger arise from it (page 404), and it holds in place the flexor tendons of the fingers and thumb and the median nerve (Plate 48, Figs. 2, 3, and 4). The anterior annular ligament is one of the most unyielding fibrous structures in the body. There are two *synovial sacs* placed beneath this ligament: one, the *larger*, lines the canal formed by the ligament arching across the carpus, and is reflected over the flexor tendons of the fingers so as to form a loose pouch four centimetres, or one and a half inches, above the ligament, while below it sends prolongations along the several tendons, forming sheaths for them as far as the middle of their corresponding metacarpal bones, except the little finger, which usually is accompanied by an extension as far as the attachment of the flexor profundus tendon at the base of the ungual phalanx. The *smaller synovial sac* is in relation to the flexor longus pollicis tendon, and extends above the annular ligament not quite so far as the other sac. It accompanies the tendon as far as its insertion into the ungual phalanx of the thumb. The tendons of the index, middle, and ring fingers are provided with *separate synovial sheaths*, which rarely communicate with the other synovial sacs, they being about two centimetres, or three-quarters of an inch, apart. The highest points of the digital sheaths usually correspond to the third flexion-line on the palmar surface, while they terminate at the bases of the ungual phalanges, so that the finger-pulps rest upon the periosteum, a fact which is often demonstrated in *felon*, or *whitlow*, by the rapid necrosis affecting the bones. This arrangement explains the fact that an abscess involving the thumb or the little finger is apt to spread to the forearm, while such an extension of suppuration does not often follow a similar affection of any of the other fingers.

The *ulnar artery* descends from the forearm in close relation to the pisiform and unciform bones, with the ulnar nerve close to its inner side. At the wrist both artery and nerve are embedded in adipose tissue and

protected by an expansion from the tendon of the flexor carpi ulnaris to the palmaris longus. Just after leaving the pisiform bone the *ulnaris profunda* is given off, and, accompanied by the deep branch of the ulnar nerve, passes between the abductor minimi digiti and flexor brevis minimi digiti muscles, while the main vessel continues between the two layers of the palmar fascia along the muscles of the ball of the little finger, two centimetres, or three-quarters of an inch, from and parallel with the linea vitalis on the surface. About midway between the latter and the linea cephalica the ulnar artery turns outward toward the web of the thumb, and, crossing over the branches of the median nerve and flexor tendons, anastomoses either with the radialis indicis or with the superficialis volæ artery, and sometimes with both, thus forming the **superficial arterial palmar arch** (Plate 48, Figs. 3 and 4). This arch is about six centimetres, or not quite two and a half inches, above the interdigital clefts. From the upper border or concavity of the arch several small recurrent branches arise which supply the carpal bursa and palmar fascia and inosculate with the carpal branches of the radial artery. From the lower border or convexity of the arch arise *four digital arteries*, which supply the fingers, except the radial side of the index and the thumb. The *first* descends over the muscles on the inner border of the palm to the ulnar side of the little finger, along which it runs to the tip. The *second*, *third*, and *fourth* descend vertically between the flexor tendons and on a line with the clefts between the fingers. About one and a half centimetres, or half an inch, above the clefts each artery, after receiving a communicating branch from the deep arch, bifurcates into two branches, which proceed along the opposed sides of the fingers as far as their tips. The lateral digital arteries in their courses freely communicate by transverse branches at the several joints, which they supply, as well as the sheaths of the tendons on both the palmar and dorsal surfaces. At the ungual phalanges the digital arteries subdivide into *palmar* and *dorsal* branches, which form plexuses in relation to the pulps of the fingers and the matrices of the nails respectively.

The *radial artery* enters the palm from the dorsal surface between the inner head of the flexor brevis and the adductor pollicis muscle (page 405),

and, after giving off the arteria princeps pollicis and the radialis indicis, continues inward as the *palmaris profunda*, under the branches of the median nerve and the flexor tendons, to anastomose with the ulnaris profunda and thus form the **deep arterial palmar arch** (Plate 48, Fig. 4). This arch is seven centimetres, or two and three-quarter inches, above the interdigital clefts. The *arteria princeps pollicis* at its origin is of large size, and passes between the abductor indicis (or first dorsal interosseous) and the adductor pollicis to the ulnar side of the palmar surface of the metacarpal bone of the thumb. In the interval between the lower portions of the flexor brevis muscle it divides into two lateral branches, which run along one or each side of the thumb and inosculate with each other similarly to the other digital arteries. The *radialis indicis artery* descends from its origin to the radial side of the index finger. Usually at the lower border of the adductor pollicis muscle this vessel communicates with the superficial palmar arch, and it often receives a branch from the princeps pollicis (Plate 48, Figs. 3 and 4). The deep arch receives three *perforating branches* from the dorsal carpal rete through the spaces between the metacarpal bones, and from its upper border gives off branches to the adjacent muscles and branches to the anterior carpal rete. From its lower border four small branches descend in relation to the palmar interosseous muscles and communicate with the digital arteries from the superficial arch, as above described. Occasionally one or more of these *interosseous branches* are substituted for the regular arteries to the fingers.

Wounds of the palm involving any of the principal arteries are always serious, in consequence of the free anastomoses between the vessels forming the arches, and of the difficulty of reaching the bleeding vessel and securing it in the wound without damaging other important structures. Nevertheless, the above procedure is the only proper one, as the hemorrhage can rarely be checked by tying either one or both of the main arteries above the wrist.

The *ulnar nerve*, after passing over the anterior annular ligament at the wrist, on the inner side of the ulnar artery, divides into a deep and a superficial palmar branch. The *deep palmar branch* supplies the muscles forming the hypothenar eminence, and accompanies the ulnaris profunda

artery to supply all the interosseous muscles, the two ulnar lumbricales, the adductor pollicis, the inner head of the flexor brevis pollicis, and the carpo-metacarpal and metacarpo-phalangeal articulations. The *superficial palmar branch* distributes filaments to the skin over the hypothenar eminence and the inner surface of the palm of the hand, and to the palmaris brevis muscle, and divides into two digital nerves, one to the ulnar side of the little finger and the other subdividing and supplying the opposed sides of the ring and little fingers (Plate 48, Fig. 4, and Plate 53, Fig. 3). The superficial branch of the ulnar communicates with the median nerve by a branch which passes beneath the superficial palmar arch.

The *median nerve* (Plate 48, Figs. 3 and 4), as it descends from the forearm under the anterior annular ligament, is enveloped in a fold of the synovial membrane. It is superficial to the flexor tendons, and as it enters the palm becomes somewhat swollen, of a pinkish color, and flattened, and divides into two branches of nearly equal size. The *external palmar branch* supplies recurrent filaments to the muscles of the ball of the thumb (the abductor pollicis, the opponens pollicis, and the outer head of the flexor brevis pollicis), and ends in three digital nerves, two to the thumb and one to the radial side of the index finger. The nerves to the thumb pass one on each side of the long flexor tendon as far as the ungual phalanx, where the outermost nerve connects with the terminal branch from the radial nerve. The nerve to the radial side of the index finger sends a filament to the first radial lumbrical muscle, and is continued to the ungual phalanx. The *internal palmar branch* of the median nerve divides into two digital branches, which pass vertically in a line with the clefts between the index and middle and the middle and ring fingers. About three centimetres, or one inch and a quarter, above the webs of the fingers the digital branches subdivide into lateral digital nerves, which are distributed as follows. The nerves from the *first* branch pass to the opposed sides of the index and middle fingers. The first digital branch also supplies the second radial lumbrical muscle. The nerves from the *second* branch pass to the opposed sides of the middle and ring fingers, receiving communicating branches from the ulnar nerve.

After many careful dissections, and repeated critical examinations on

the living regarding the cutaneous distribution of the various digital nerves, the author is inclined to believe that the arrangement as shown (Plate 53, Figs. 2 and 3) may be considered to represent their usual relations. It should be remembered that there is commingling of the fibres of the median and ulnar nerves by direct intercommunicating nerves both above and below the wrist, which probably accounts for the discrepancy in the observations on this subject. The extremities of the digital nerves are provided with peculiar little bodies, the *Pacinian corpuscles*, which are found in greater number on the nerves of the thumb and the index finger. Their function is unknown. The cutaneous nerve-supply of the hand is remarkable for the high development and the great number of the *tactile corpuscles*, which give to it an extraordinarily acute degree of tactile sensibility. The most sensitive area is the palmar surface of the tips of the fingers, and especially that of the ungual phalanx of the index finger. The dorsal surface of the hand is the least sensitive, as already stated.

The *superficial lymphatic vessels* commence by palmar and dorsal vessels on each finger, which unite and form plexuses on the palmar and dorsal surfaces of the hand respectively. Those of the palmar plexus are small and very close, and are arranged in an arch, from which vessels pass up the forearm accompanying the superficial veins. Those of the dorsal plexus are comparatively larger and more numerous, and their vessels wind round the borders of the forearm above the wrist and join with the vessels from the palmar plexus. The deep lymphatic vessels accompany the venæ comites of the radial and ulnar arteries.

The nails are the horny plates which surmount the finger-tips upon their dorsal surfaces, and may be regarded as modified appendages of the epidermis. Each nail rests upon the extremely vascular and sensitive *nail-bed* of the dermis, the upper portion of which is called the *matrix*, whose papillæ are arranged in ridges and protected by a fold of the skin. The part of the nail in relation to the matrix is the *root*. It is the thinnest part, and appears white and opaque just in front of the fold of the skin, and, owing to its crescent shape, is called the *lunula*. The latter is always more pronounced in the thumb than in the fingers. The growth of the nails is like that of the epidermis, by an incessant production of

nail-cells in the nail-bed, so that as long as the matrix is preserved the nail is capable of reproduction. The nails vary in individuals, and under certain constitutional conditions are probably influenced by impeded circulation, for there appears to be a direct communication between the arteries and the veins in the matrix. It is noteworthy that during convalescence from many of the exanthematous diseases grooves make their appearance across the nails, presenting indications of growth. As the digital nerves supply large terminal filaments to the nail-beds, it is not difficult to account for the intense pain which is experienced when a splinter or other foreign body is thrust beneath the nails.

The *development of the bones of the wrist and hand* occurs at varying periods. At birth the carpal bones are all cartilaginous. The os magnum becomes ossified in the first year, the unciform in the second, the cuneiform in the third, the trapezium in the fourth, the semilunar in the fifth, the scaphoid in the sixth, the trapezoid in the seventh, and the pisiform not generally before the twelfth.

The metacarpal bones and the phalanges are usually composed of a shaft and an *upper* epiphysis. The shafts become ossified soon after birth, and the epiphyses are all united about the twentieth year.

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THE REFERENCES TO SURGICAL AFFECTIONS OR PROCEDURES (MARKED *) RELATE TO THEIR ANATOMY ONLY.

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